Public Review Draft

Recommendations of Independent Science Advisors for The California Desert Renewable Energy Conservation Plan (DRECP)

Prepared For
Renewable Energy Action Team:

California Department of Fish & Game
U.S. Fish & Wildlife Service
U.S. Bureau of Land Management
California Energy Commission

Prepared By
The DRECP Independent Science Advisors

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Table of Contents

1 Introduction

This report summarizes recommendations from a group of independent science advisors[1] for the California Desert Renewable Energy Conservation Plan (DRECP). DRECP will be a Natural Community Conservation Plan (NCCP) under California's NCCP Act of 2003. It may also serve as one or more Habitat Conservation Plans (HCP) under Section 10 of the U.S. Endangered Species Act. The NCCP Act requires input from independent scientific experts to ensure that plan decisions are informed by best available science. The advisors include experts in desert ecology, conservation biology, and other fields pertinent to informing how to conserve natural ecological communities and species in the planning region. Appendix A provides brief biographies of the advisors.

To ensure objectivity, the advisors operate independent of the plan applicants, their consultants, and other entities involved in the plan. Our recommendations are not legally binding on agencies or individuals involved in planning or implementing DRECP.

Contents of this report reflect the advisors' review of available information and maps of the DRECP process and planning area, results of a two-day science advisors' workshop, and subsequent research and discussions amongst the advisors. The science advisors met April 22-23, 2010, to hear the concerns of plan participants and begin formulating recommendations. Advisors were also encouraged to seek expert input from other scientists. We also reviewed various questions and comments submitted by agencies, stakeholders, and other interested parties before, during, and after the April 2010 science workshop (available at http://www.energy.ca.gov/33by2020/documents/). However, we made no attempt to specifically address submitted questions in a question-answer or response-to-comments format. Instead, we have attempted to address appropriate questions and comments intrinsically within our recommendations.

In general, our recommendations are organized to address four sets of principles for which the NCCP Act requires independent science input: principles for addressing data gaps and uncertainties; principles for conservation and reserve design; principles for conserving specific target species and natural communities; and principles and framework for an adaptive management and monitoring program. We also address certain aspects of the plan scope, including the geographic area, time period, species, natural communities, and actions that the plan is to cover. A previous draft of this report was circulated to other scientists for peer review, and comments received from four reviewers[2] are reflected in this draft.

[1] Dr. Wayne Spencer, Conservation Biology Institute (Lead Advisor); Dr. Scott Abella, UNLV; Dr. Cameron Barrows, UC Riverside; Dr. Kristin Berry, USGS; Dr. Todd Esque, USGS; Kimball Garrett, Natural History Museum of LA County; Dr. Christine A. Howell, PRBO Conservation Science; Robin Kobaly, The SummertTree Institute; Dr. Reed Noss, U Central Florida; Dr.Richard Redak, UC Riverside; Dr. Robert Webb, USGS; Ted Weller, US Forest Service.

[2] Dr. Paul Beier, Northern Arizona U; Dr. James Patton, UC Berkeley (Emeritus); Dr. David Bedford, USGS; Mark Jorgensen, Anza Borrego Desert State Park (retired).

1.1 Philosophy and Approach

The advisors strongly agree that increasing the U.S. and California supply of renewable energy can yield numerous environmental and societal benefits, and that California's deserts have great potential for wind, solar, and geothermal energy production. However, siting and developing renewable energy developments must be done carefully, guided by best available science, to avoid undue damage to fragile desert ecosystems. Despite a widespread perception that our deserts are relatively pristine and secure, many desert species, natural communities, and ecological processes are already severely stressed by myriad human-induced changes to the landscape (Lovich and Bainbridge 1999, Berry and Murphy 2006, Bunn et al. 2007, Pavlik 2008, Webb et al. 2009a). Additional stress from direct and indirect effects of energy developments, in concert with a changing climate, portends further ecological degradation and the potential for species extinctions. Our intent is therefore to provide science-based recommendations for minimizing the adverse effects of energy developments on desert ecosystems and for contributing to the conservation and recovery of desert biota and ecosystem functions.

We understand that there are differences in the nature of impacts and mitigation actions among the various types of energy technologies, and that these technologies continue to evolve. However, we are not experts in renewable energy development, and our recommendations should be seen as one critical set of considerations for siting and designing renewable energy developments and mitigating adverse effects. We therefore have strived to allow for some flexibility in applying our recommendations.

We also understand that time is of the essence, and that fully complying with all of our recommendations prior to plan completion could cause significant delays. *This should not be used as an excuse to either ignore recommendations or to delay the plan to implement all recommendations.* We assume that in reviewing our recommendations, the planning team will determine which of them can and should be implemented immediately, and which can and should be implemented incrementally during planning, or even during plan implementation, as part of the recommended adaptive management process. For example, although we recommend a variety of field surveys and GIS-based modeling approaches to address information gaps, not all of these could feasibly be implemented in the near term, before important plan decisions must be made about siting developments or conservation actions. *We therefore strongly advocate using "no regrets" strategies in the near term—such as siting developments only in already disturbed areas—as more refined analyses become available to guide more difficult decisions*.

Finally, human understanding of desert ecosystems and species, and how they may be affected by various conservation, management, and development actions, is constantly evolving. We strongly encourage planners to recognize the dynamic nature of scientific knowledge and to seek and embrace continuous scientific input throughout the planning process and beyond. In essence, the plan should be treated as a huge environmental experiment with many uncertain outcomes. *This requires that the plan be developed and implemented incrementally in an adaptive management framework—with continuous monitoring and scientific evaluation to reduce uncertainties and improve plan actions over time*.

1.2 Overarching Issues and Recommendations

The advisors want to emphasize several overarching concerns and recommendations that permeate the more detailed recommendations that follow:

General Assumptions and Recommendations

- *Our recommendations only apply to a plan to facilitate renewable energy developments and their appurtenant facilities, and conservation and mitigation actions for biological resources*; they do *not* apply to other sorts of development, such as urban expansion, golf courses, or biofuels production (i.e., agricultural development). Such actions could fundamentally alter our assumptions and recommendations and would therefore require additional scientific input. Our recommendations also do not address other environmental impacts of renewable energy development, such as to cultural or scenic resources.
- *Every effort should be made to avoid and minimize any new disturbance of soil surfaces in the siting, design, construction, and maintenance of any and all project features.* Arid ecosystems are strongly shaped by characteristics of soils and other geological surfaces that develop over millennia and that cannot be replicated by human actions. *Therefore, ecological impacts of projects that alter surficial geology should be presumed permanent, despite any good intentions or promises to decommission renewable energy projects at the end of their useful life and restore what came before*. This does not mean that well-conceived efforts to decommission, restore, and revegetate have no ecological value, however—only that such actions can never be assumed to replicate original nature, and therefore cannot be considered full mitigation for the original impact.
- *Obtain additional independent scientific input and review of data, models, maps, and other analytical tools and products* at important milestones during the planning process. Given the huge scope of the plan, the complexity of the issues, and the limited time we've had to research and prepare this report, we suggest that additional scientific input and review of interim products will help reduce uncertainties, avoid costly errors, build support, and increase the potential to meet DRECP goals. For example, we recommend convening independent scientists to review any environmental data layers to be used for planning or analysis (e.g., new or revised vegetation maps or species distribution maps). Scientists should also provide guidance to, and review of, any models to be used during the process, including GIS overlay models, species distribution models, population models, reserve-design algorithms, and climate change models. An important function of periodic scientific review of conservation plans is to ensure that planners followed the recommendations of earlier independent scientific input—or provide valid reasons for not having followed earlier recommendations—and to make course corrections if necessary before it is too late.

Data and Analytical Tools

- *Invest in completing a seamless, up-to-date, high-resolution, hierarchical vegetation (or landcover) map* as soon as possible to support conservation planning, renewable energy facility siting, and conservation analyses. The lack of a comprehensive and dependable land-cover base map—which is an essential data layer for spatially explicit models, maps, and analyses—is a key information gap faced by the plan. This hinders the ability to reasonably predict the plan's effects on target species and communities and to locate appropriate conservation and mitigation actions. The State Mapping Program (headed by Dr. Todd Keeler-Wolf, CDFG) has been mapping large areas of the state using the National Vegetation Classification System (NVCS) tailored for California, and represents the best available database. However, the program has only mapped about 60% of the Mojave Desert in California, and further progress is apparently hindered by funding constraints. This mapping effort should be funded, with *priority given to completing mapping for the rest of the DRECP planning area as soon as possible*. To allow the plan to make progress while this detailed mapping is completed (an estimated 18 months, given adequate funding), we recommend creating an "interim" or mid-level vegetation map by compiling new and existing vegetation maps, reformatting to allow for standardized representation at a mid-level hierarchy (e.g., using vegetation alliances or alliance groups), and edge-matching appropriately with adjoining states and Mexico.

- *Avoid using species observation locality data (e.g., from the California Natural Diversity Data Base, CNDDB) as a primary foundation for siting developments or conservation actions, and do not assume that absence of species observations means absence of the species*. Although CNDDB data are valuable, there are limitations to how they should be used to avoid misunderstandings. The advisors do not have faith in the interpretation of the "species sensitivity ranking" maps prepared by the Renewable Energy Action Team (REAT) that "the darker the color the higher the sensitivity." In part this is because we were not provided details concerning the ranking methods and criteria, and in part because CNDDB data were apparently the primary inputs. CNDDB data (and many other sorts of resource locality data) are presence-only data, and one cannot assume that areas lacking locality data (or "lighter in color") represent absence of species or low biological value. Moreover, CNDDB data exclude numerous available species locality data sources, do not reliably track taxa not considered rare, and generally do not differentiate among subspecies. This is important because there are many subspecies of conservation concern in the DRECP planning area that cannot be reliably located using CNDDB. Finally, for species or subspecies only recently designated as being of conservation concern, there may be few or no CNDDB entries. *CNDDB data are best used as inputs to spatially explicit distribution models (see below) or as supplements to other information sources rather than as primary predictors of species distribution and especially species absence*.

- Related to the preceding recommendation, *use appropriate, spatially explicit, dynamic, probabilistic maps and models to address information gaps* to the degree feasible. Examples include empirical (statistical) models of a species' probability of occurrence across the landscape based on survey data (e.g., Spencer et al. In Press)—or where survey data are inadequate, scientifically defensible habitat distribution models (e.g., Early et al. 2008); dynamic maps of ecological shifts expected under climate change (e.g., Stralberg et al. 2009, Wiens et al. 2009); and spatially explicit population models (e.g., Carroll et al. 2003, Carroll et al. In Press, Spencer et al. In Press) for select covered species having sufficient data (such as desert tortoise and bighorn sheep). Subject all such models to scientific peer review, sensitivity analysis, and quality assurance procedures to ensure reliability.

- *Make all analyses and decision-making processes as transparent and understandable as possible, and avoid maps that compile multiple data inputs into a single data layer without adequate documentation and justification.* For example, the advisors reviewed maps prepared by the REAT showing "conservation opportunity areas" that were described as supporting "key populations or connections between key populations." Compositing this information into a single map color without differentiating the various species populations or connections comprising it, and without explaining the methods used to produce the composite, made it difficult for advisors (or the public) to understand the potential value or application of these maps. Moreover, this makes it impossible to compare differing biological values or constraints on different parts of the map, which is essential to insightful prioritizing or phasing of conservation actions. Future maps should clearly differentiate, for example, existing reserve areas, unconserved areas, habitat connectivity areas, species' ranges, or other important inputs to inform decision making. If a single summary or composite map is desired for simplicity (e.g., for public outreach), the individual data layers and how they were derived and treated in the composite should still be made available, and the compositing criteria and methods clearly articulated.

- *Match the scale and resolution of each analytical task to the scale and resolution of the issues being addressed.* Some aspects of the conservation design and analysis of plan effects could be performed over the entire planning area at relatively coarse resolution—such as a "GAP analysis"[3] of existing protected areas—whereas other issues—such as how the plan may affect populations of select covered species—should be performed at finer resolution over smaller portions of the planning area to increase their sensitivity and reliability. *Do not attempt "one-size-fits-all" approaches for designing and analyzing all aspects of the plan*.
- Related to the preceding recommendation, we recommend *subdividing the planning area into ecologically relevant planning subunits* that account for heterogeneity in climate, vegetation, geology, etc., across the region. Subdivisions could be based, for example, on the Ecological Sections and Subsections delineated by the USDA and USDI (Miles et al. 1998) or the units delineated for the Mojave Desert by Webb et al. (2009a). Ecologically relevant subdivisions can help account for geographic variations in, for example, the habitat affinities and physiological tolerances of species when using habitat suitability or climate-change sensitivity models. They can also help focus mitigation measures appropriately within areas where impacts occur. It would therefore be desirable for individual planning units to contain one or more clusters of proposed renewable energy projects or zones.

Siting and Mitigation Recommendations

- To the degree possible, *site all renewable energy developments on previously disturbed land* (areas where grading, grubbing, agriculture, or other actions have substantially altered vegetation or broken the soil surface); and *site all linear facilities within or alongside existing linear rights-of-way, paved roads, canals, or other existing linear disturbances, so long as this does not create complete barriers to wildlife movements or ecological flows*. Habitat fragmentation and impediments to wildlife movements are among the greatest threats to desert communities and species, and maximizing habitat connectivity is essential to climate change adaptation. The plan should embrace a primary goal of *avoiding and minimizing any additional habitat loss or fragmentation*. "Bundling" of developments along

[3] A Gap Analysis is a quantitative, spatial assessment of how well a network of reserves protects elements of biodiversity. The "gaps" are those areas or elements not adequately represented within the reserve system.

such features as existing roads, transmission lines, and canals will help minimize additional fragmentation impacts, although there is potential for this to increase barrier effects of existing features to wildlife movement or ecological flows. The combined effects of both new and existing (or bundled) linear features on wildlife movement should be mitigated with appropriate crossing structures or corridors to facilitate wildlife movement, coupled with appropriate fencing to minimize roadkill and funnel wildlife to crossing structures.

- *Implement and improve on conservation actions identified by existing conservation and recovery plans in the planning area*, such as the Western Mojave Desert Plan, the Northern and Eastern Mojave Desert Plan, the Northern and Eastern Colorado Desert Plan, and the Desert Tortoise Recovery Plan. Considerable scientific input has already been applied in these plans to delineate important conservation areas and design specific conservation and mitigation actions to preserve and recover sensitive desert species and communities. However, most of these conservation actions have never been fully implemented due to funding and staffing constraints at the responsible agencies (Bunn et al. 2007). *Mitigation for renewable energy developments should be used to help rectify this situation by providing funding to implement appropriate existing conservation plans and recommended recovery actions, and to improve these plans over time via the DRECP Adaptive Management and Monitoring Program*. In addition, The Nature Conservancy, SCWildlands, California Partners in Flight (CalPIF), and other conservation NGOs have been developing science-based maps and plans for conserving desert resources, and although the science advisors have not comprehensively reviewed their work or compared their approaches with our recommendations, we believe such assessments are valuable references for identifying important conservation areas and actions. To be efficient, *DRECP should use such existing conservation assessments and plans to advantage, supplementing and improving on them with peer review, as necessary, and with due consideration of our other recommendations*.
- Consider how energy developments may affect geomorphic systems and processes that sustain ecosystems and *avoid siting developments where they will disrupt essential physical geological processes.* Two important examples are eolian (wind-driven) systems such as active sand dunes, and low-slope alluvial fans that produce sheetwash that sustains downslope desert vegetation through runon. Avoid developments that might affect the production, transport, or settling of wind-blown sands or that could divert, disrupt, or channelize natural sheetflows.
- *Encourage renewable energy developments that maximize energy produced per unit land area.* Land disturbance for project footprints should be minimized to the degree feasible while maximizing energy production.
- *Encourage renewable energy developments that use less water*, such as air-cooled generators, to minimize groundwater overdraft. Groundwater flow paths should be clearly understood within the vicinity of water-cooled generation facilities to avoid impacts on groundwater-fed riparian ecosystems. *Water use from alluvial aquifers, such as those along the Mojave and Amargosa rivers, should be avoided to minimize impacts on riparian resources*.

2 Plan Scope

The scope of a conservation plan includes its biological goals, geographic extent, permit duration, species and communities to be addressed, and actions to be permitted.

2.1 Biological Goals

The delineation of clear objectives with measurable outcomes is central to the success of conservation planning. Objectives should guide the selection of conservation targets or goals, the structure of impact analyses, and the targets and measures selected for monitoring.

The NCCP Act (Sher 2001, California Senate Bill No. 107) states that the purpose of NCCP planning is "to sustain and restore those species and their habitat… that are necessary to maintain the continued viability of those biological communities impacted by human changes to the landscape" and that "it is the policy of the state to conserve, protect, restore, and enhance natural communities." Thus, while one objective of NCCPs and HCPs is to obtain authorizations (or permits) to "take" some habitat or individuals of listed or otherwise sensitive species, the broader goals are to sustain, restore, and enhance biological diversity and ecological functionality in general. The advisors recommend that the plan's overarching goal should be to *contribute to the persistence, distribution, and diversity of the desert biota and all its natural components and processes today and into the future, while accommodating renewable energy development and adapting to climate change*.

To create a plan that meets the goals of the NCCP Act, the advisors recommend that the plan (1) include explicit, hierarchical goals for the maintenance of biological diversity and ecosystem function in addition to goals for listed or sensitive species intended for permit coverage; (2) evaluate the impact of various planning scenarios on those biodiversity and ecosystem function goals, in addition to evaluating impacts on covered species; and (3) choose conservation strategies and policies that best satisfy this suite of biological goals while also meeting renewable energy goals.

2.2 Geographic Extent of Plan Area

The large geographic area addressed by the DRECP (Figure 1) is unprecedented for an NCCP and introduces tremendous complexity to the planning process. The plan area includes parts of the Great Basin, Mojave, and western Sonoran (or Colorado) deserts, as well as ecotones of these desert communities with the adjacent ecosystems in the Sierra Nevada, Tehachapi Mountains, Transverse Ranges (Western Transverse Ranges, San Gabriel, and San Bernardino mountains), and Peninsular Ranges (Baldwin et al. 2002). Three floristic and geographic subdivisions of California are represented: the California Floristic Province, Great Basin Province, and Desert Province. These floristic and geographic subdivisions can be further divided into regions based on climate (precipitation and temperature patterns), floristics, topography, and geology (e.g., Rowlands et al. 1982, 1995; Miles et al. 1998; Hereford et al. 2006; Webb et al. 2009a).

This large size and tremendous biogeographic and climatic diversity will make planning and analysis especially challenging. Species are naturally distributed unevenly across the landscape, and the spatial scale and resolution need to be fit appropriately to each organism and analysis. In some cases analyses should be done at a subregional or local scale, while other analyses may need to cover the entire planning area. For example, for some species a single habitat suitability or climate-change sensitivity model covering the entire planning area may be less accurate than several subregional models that can account for differences in how a particular species selects habitat or responds physiologically to climate variables in different geographic regions. We therefore recommend dividing the planning area into several regions or planning units that are both ecologically relevant and potentially useful for dealing with the likely clustering of renewable energy developments in different regions. Examples of appropriate subdivisions include the Ecological Sections and Subsections delineated by the USDA and USDI (Miles et al. 1998; http://www.fs.fed.us/r5/projects/ecoregions/toc.htm) or the subdivisions delineated by Webb et al. (2009a) for the Mojave Desert. Figure 2 illustrates the Ecological Subsections of the Mojave Desert as delineated by Miles et al. (1998) (similar Subsection maps exist for the Sonoran and Colorado Desert Sections in California but are not included here). Figure 3 illustrates the Subdivisions of the Mojave Desert as recognized by Webb et al. 2009a). Note that Webb et al. (2009a) only covered the Mojave Desert, so if their system is used, similar subdivisions would need to be delineated for the Sonoran and Colorado deserts to recognize such regions as the Coachella Valley, Borrego Valley-West Mesa, Imperial Valley, and East Mesa-Sand Hills.

It is evident from various maps of proposed energy developments (e.g., BLM Solar Study Areas, Commercial Renewable Energy Zones [CREZ], and solar lease applications) that the developments are likely to be clustered. This suggests that conservation planning, impact analyses, and mitigation requirements should be focused at scales and in areas relevant to the clustered footprints of these likely renewable energy areas. Subdividing should therefore also consider likely clustering patterns, such that individual planning units include one or more of these clusters. This would focus conservation and mitigation actions appropriately within the affected regions.

We understand that the planning area was expanded beyond the deserts proper to include some adjacent mountain watersheds that have high wind-energy potential. The advisors point out that this adds even more complexity to the plan by affecting a wider array of non-desert communities and species. We are also unclear why this expansion into mountainous areas of high wind potential was not done consistently along the planning boundary—in particular why the planning area ends along the eastern boundary of San Diego County rather than including areas of high wind potential in the Peninsular Ranges to the west (NREL 50-m wind resource map; http://www.windpoweringamerica.gov/maps_template.asp?stateab=ca).

Figure 1. The DRECP Planning Area (Courtesy of CDFG).

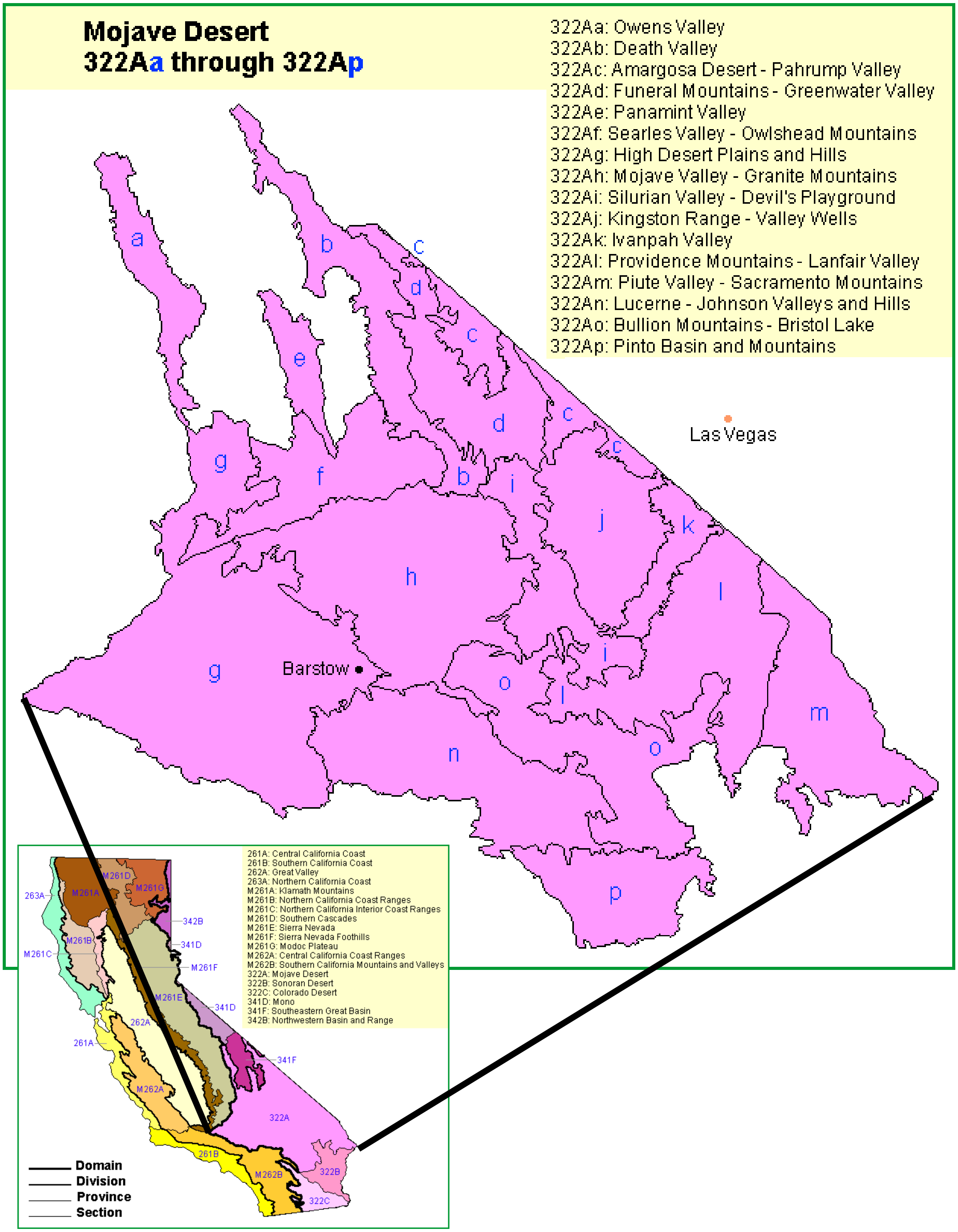

Figure 2. Ecological Subsections of the Mojave Desert Section in California as delineated by Miles et al. (1998). The inset shows Ecological Sections in California.

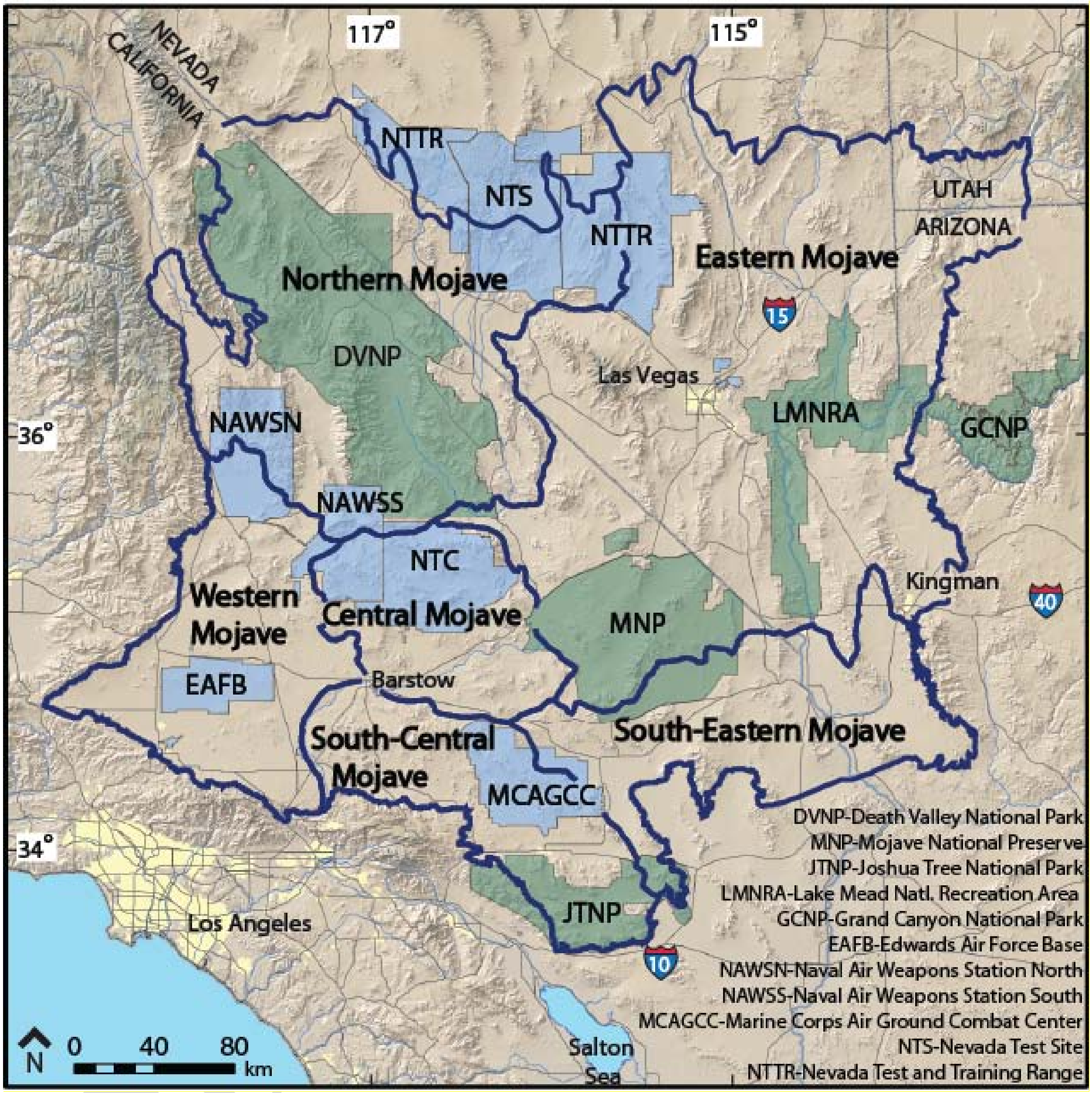

Figure 3. Subdivisions in the Mojave Desert delineated by Webb et al. (2009a).

2.3 Permit Duration

A permit term of 30 or 50 years is common for regional conservation plans (Rahn et al. 2006). *The advisors recommend 30 years as the maximum that is scientifically defensible in light of environmental variability, the pace of climate change, and the likely life of energy developments.* We do *not* support a longer (e.g., 50-year) duration, due to increasing uncertainties about biological effects, climate shifts, and technological changes with longer durations.

Regardless of permit duration, protections offered to biological resources (e.g., reserve areas and their management) are expected to continue in perpetuity. There should be no "walk-off" option, such that these protections are voided at the end of the permit duration. The plan should have built in requirements (such as bond funds) to ensure that remedial actions, such as decommissioning and ecological restoration, are implemented at the end of a development's useful life and that appropriate protections and management actions are continued in perpetuity. However, in recognition of the very long-term effects of surface disturbance in the desert, locations permitted for renewable energy may best be reused for similar purposes in the future (using whatever appropriate or best renewable energy technology is available at that time). If there is no need to reuse previously disturbed sites for new projects in the future, decommissioning and ecological restoration should be done using the best available and scientifically justified methods available at that time, recognizing that our current understanding of desert restoration is rudimentary. Although decommissioning and restoration may benefit DRECP species and communities, however, these future actions cannot be assumed to fully restore the original ecological conditions or full biological value of these sites, and remedial actions at the end of a project's life cannot be considered full mitigation for the project.

We also stress the importance of an effective monitoring and adaptive management program to ensure that plan goals are being met within and beyond any permit duration. Science-informed management intervention will be required to address changing conditions, including climate change, within and beyond the permit horizon. *We recommend that species statuses, species distributions, conservation needs, and other important aspects of the plan be reassessed at least every 10 years in light of changing conditions and accumulating information.*

2.4 Natural Communities

The plan should address the needs of whole, intact, natural communities and mosaics of communities at the landscape scale to accommodate natural ecological processes, including range shifts, rather than focusing just on individual species. The planning area supports hundreds of species—described, undescribed, and as of yet undiscovered—that are endemic to isolated communities or special habitat features, such as wetlands, desert wash woodlands, unique soil types, and active sand dunes. The only way to deal effectively with such species is to deal with entire communities, rather than focusing on the individual needs of every constituent species. Rare or unique desert communities and special features (such as dunes and springs), and the processes that sustain them (e.g., sand transport for dunes, groundwater aquifers for wetlands), should be "covered" by the plan in that they should be avoided to the degree possible by development and they should be foci for conservation actions. The plan should have a goal of no anthropogenically induced loss of the rare natural communities, special features, and ecological processes described below.

Active sand dunes provide a stark example of the high degree of endemism in isolated and unique desert communities or features. The insular distribution of desert dunes, coupled with challenging habitat conditions, has resulted in isolation, local adaptations, and speciation. The Kelso Dunes alone have 10 described endemic arthropods (eight beetles, a sand-treader cricket, and a Jerusalem cricket); the Algodones Dunes have eight (seven beetles, one sand-treader cricket); and every southern California dune system that has received any level of taxonomic surveys has one or more endemic arthropods (at least 30 or 40 overall).

2.4.1 Vegetation Alliances and Unique Plant Assemblages

We recommend using the list of California Terrestrial Natural Communities and California Vegetation Alliances included as Appendix B (provided by Dr. Todd Keeler-Wolf, California Department of Fish and Game, June 2010) to define natural communities and vegetation alliances by region. These Natural Communities and Vegetation Alliances for the state are based on Grossman et al. (1998), Holland (1986), and Sawyer et al. (2009). Over 150 vegetation alliances occur in the planning area. Those that are composed of native species, are endemic to the state, have limited distributions, and are essential to supporting covered plant and animal species should be given conservation attention.

The advisors recommend that special protective measures be taken to conserve Unique Plant Assemblages (UPAs), Stands, or Vegetation Alliances that are limited in distribution or that support sensitive or endemic species (U.S. Department of the Interior, Bureau of Land Management 1980, California Department of Fish and Game 2009). These include the following:

- Those UPAs listed and shown on maps in the California Desert Conservation Area Plan (CDCA) of 1980 as amended. The categories in the CDCA Plan should serve as a starting point and are repeated here for convenience with a few examples: Great Basin enclaves; coastal California enclaves; montane enclaves (e.g., white fir forests in Clark, New York, and Kingston mountains); enclaves of unknown affinities (e.g. Chuckwalla Bench/Chocolate Mountains Munz cholla); plant assemblages that reach their range limits within the California deserts; unusual psammophytic (sand-dependent) assemblages; plant assemblages associated with springs, seeps, and near-surface waters; plant assemblages with unusually high density or cover of some particular species (e.g., Davies Valley Succulent Scrub Assemblage); and plant assemblages with individual members of which attain great age and/or size. Two additional examples from the CDCA are listed below, the first with a new title from the list of plant alliances:
    - Spinescale Scrub Alliance, dominated by *Atriplex spinifera* [aka Mojave saltbush]
    - Crucifixion Thorn Stands (*Castela emory*), a Special Stand

- Vegetation Alliances and UPAs associated with rivers, marshes, springs, seeps, near-surface waters, washes, ephemeral standing waters (small and large playas), and ephemeral standing waters adjacent to dune systems. A few examples are:

- Desert willow woodland (*Chilopsis linearis* Alliance)
- Blue palo verde-Ironwood woodland (*Parkinsonia florida-Olneya tesota* Alliance)
- Smoke tree woodland (*Psorothamnus spinosus* Alliance)
- Fremont cottonwood forest (*Populus fremontii* Alliance)
- Arroyo willow thickets (*Salix lasiolepis* Alliance)
- Yellow willow thickets *(Salix lutea* Alliance)
- Mesquite bosque, mesquite thicket (*Prosopis glandulosa* Alliance)
- Screwbean mesquite bosques (*Prosopis pubescens* Alliance)
- Mulefat thickets (*Baccharis salicifolia* Alliance)
- Black-stem rabbitbrush scrub (*Ericameria paniculata* Alliance)
- Scale-broom scrub (*Lepidospartum squamatum* Alliance)
- Bladder sage scrub (*Salazaria mexicana* Alliance)
- Yerba mansa (*Anemopsis californica*) meadows (e.g., in Afton Canyon)
- Desert panic grass patches (*Panicum urvilleanum*) (e.g., along the Mojave River)
- California fan palm oasis (*Washingtonia filifera* Alliance)

- Vegetation Alliances associated with rare, threatened, and endangered animals, e.g.:
  - Creosote bush-white bur sage scrub (*Larrea tridentata-Ambrosia dumosa* Alliance) supporting big galleta (*Pleuraphis rigida*) or a diverse shrub layer
  - Spinescale Scrub Alliance, dominated by *Atriplex spinifera* [aka Mojave saltbush]
  - Spiny hop sage scrub (*Grayia spinosa* Alliance)

- Once wide-spread vegetation alliances, now limited and rapidly diminishing because of development, e.g.:
  - California poppy fields (*Eschscholzia californica*)
  - Joshua Tree Woodlands alliance (*Yucca brevifolia* alliance)—diminished stands in western Mojave Desert

Current scientific standards are available for classifying the uniqueness of vegetation alliances through NatureServe's Community Heritage Program, which is internationally recognized as the Natural Communities Conservation Ranking system. This system includes global uniqueness ranking (G rankings) and state (S rankings) as well as a threats ranking. It therefore provides recognition of rare and unusual plant assemblages. The ranking is categorized into five distributions. The advisors recommended that vegetation alliances occurring within the following global and state rankings be covered by DRECP:

- G1, S1 – critically imperiled; fewer than 6 viable occurrences worldwide/statewide and/or up to 518 hectares known;
- G2, S2 – imperiled; 6-20 viable occurrences worldwide/statewide and/or more than 518 – 2,950 hectares known;
- G3, S3 – vulnerable; 21-100 viable occurrences worldwide/statewide and/or more than 2,950 – 12,950 hectares known.

These rankings capture not only the rarity of the alliance within the state boundaries but also outside of the state. All of these alliance rankings are considered "rare and threatened" throughout the alliance's range (Sawyer et al. 2009). High priority for conservation should be focused on those alliances and associations that have a threat ranking of 0.1 (Very Threatened) and 0.2 (Threatened). Because our knowledge of the distribution of rare and unusual vegetation alliances in the California desert is currently incomplete, it is imperative that additional vegetation mapping be completed throughout the desert regions. The advisors recommend that new data be incorporated into the database for the DRECP, and recognized and incorporated through the adaptive management strategy.

2.5 Covered Species

Typically, NCCP/HCPs identify a list of species[4] to be covered by "take authorizations" using several selection criteria, including their conservation status, occurrence in the plan area, likelihood of being affected by plan actions, and sufficiency of knowledge to determine plan effects: We agree with this general approach, but offer some further guidance concerning these selection criteria:

- **Conservation Status.** Covered species typically include those species, subspecies, or distinct population segments (hereafter, collectively called species) that are listed under state or federal Endangered Species Acts or that are considered likely to be listed during the plan's permit duration. These generally include California "Species of Special Concern" (also known as the Special Animals List) or other taxa that meet one or more criteria for listing as threatened or endangered but that have not been legally protected.
- **Occurrence in Plan Area**. Consideration should be given to all species known or likely to occur in the planning area, *during the plan's permit duration*. Note that it is quite possible that some species not currently known from the planning area could enter the planning area over the next 30 to 50 years due to climate change or other dynamics.
- **Plan Effects**. Species likely to be affected, whether positively or negatively. Often, planners only consider those species that may be adversely affected ("taken") by covered actions. However, some species may benefit from the conservation actions in the plan although they may not be adversely affected by development of renewable energy facilities.
- **Information Adequacy**. Species for which we do not have adequate information to determine how covered actions may affect them, or what conservation actions may benefit them, are often omitted from covered species lists. However, we recommend that the covered species list be kept relatively comprehensive despite such uncertainties. Data gaps that interfere with our ability to assess plan effects can be reduced over time via the adaptive management and monitoring program, ecological research, and advances in predictive modeling (e.g., for species' distributions and responses to plan actions or climate change). However, if little-known species are left off the covered species list due to information gaps, they are less likely to garner the research and monitoring attention needed to close those gaps and ensure their conservation.

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[4] Note that under the Endangered Species Act, species, subspecies, or distinct population segments can be listed as threatened or endangered. Distinct population segments are populations of a species that are distinct, relatively reproductively isolated from other populations of the species, and represent a significant evolutionary lineage of the species. Throughout this document, we use the word species to refer to all three categories (species, subspecies, or distinct population segment).

The advisors reviewed a preliminary list of species of "planning interest" included in Exhibit B of the DRECP Planning Agreement (dated March 2010; Table 1). We noted a variety of errors, including inappropriate inclusion of full species rather than subspecies of conservation concern, inclusion of species not found in the planning area, exclusion of species or subspecies of conservation concern that do occur in the plan area, and apparently a lack of consideration of information from previous conservation and recovery plans. The following sections address these issues in more detail by major taxonomic groupings. They provide *examples* of apparent errors of omission and commission in the current species list and recommendations for assembling a more defensible covered species list. *We recommend that DRECP form a committee or subcommittee of qualified biologists to prepare a proposed covered species list based on the factors described above, and considering information presented in this section.*

We also recommend that any *future lists of species produced for DRECP be organized in traditional taxonomic order using scientific nomenclature*. The current list included as Table 1 is organized alphabetically by common name, with no regard for taxonomic hierarchy or species relations. Some species and subspecies of conservation concern in the planning area do not have common names and can only be identified by scientific name. Because there is no standardized list of common names for most taxa (with the exception of North American birds, for which the American Ornithologists Union establishes standardized list) multiple species may share the same common name, or the same species may have multiple names. Scientific nomenclature exists to avoid such confusion.

Table 1. "Preliminary list of species of planning interest" included as Exhibit B of the DRECP Planning Agreement (March 2010). *This is **not** included here as a recommended covered species list because it contains errors and requires substantial revision (see text).*

Common Name	Scientific Name	CESA	ESA	California Special Concern	BLM Sensitive
ANIMALS					
Arizona myotis	*Myotis occultus*			X	
Arroyo toad	*Anaxyrus californicus*		Endangered		
Arroyo toad	*Bufo californicus*			X	
Bald eagle	*Haliaeetus leucocephalus*	Endangered	Delisted		
Barefoot gecko	*Coleonyx switaki*	Threatened			
Bendire's thrasher	*Toxostoma bendirei*				X
Bewick's wren	*Thryomanes bewickii*			X	
Big free-tailed bat	*Nyctinomops macrotis*			X	
Bighorn sheep	*Ovis canadensis*	Threatened	Endangered		
Burrowing owl	*Athene cunicularia*			X	X
Cactus wren	*Campylorhynchus brunneicapillus*			X	
California black rail	*Laterallus jamaicensis coturniculus*	Threatened			
California condor	*Gymnogyps californianus*	Endangered	Endangered		
California leaf-nosed bat	*Macrotus californicus*			X	X

Common Name	Scientific Name	CESA	ESA	California Special Concern	BLM Sensitive
California pocket mouse	*Chaetodipus californicus*			X	
Cave myotis	*Myotis velifer*			X	X
Coachella Valley fringe-toed lizard	*Uma inornata*	Endangered	Threatened		
Coachwhip	*Masticophis flagellum*			X	
Colorado desert fringe-toed lizard	*Uma notata*			X	X
Common ensatina	*Ensatina eschscholtzii*			X	X
Common yellowthroat	*Geothlypis trichas*			X	
Crissal thrasher	*Toxostoma crissale*			X	
Desert night lizard	*Xantusia vigilis*			X	
Desert tortoise	*Gopherus agassizii*	Threatened	Threatened		
Desert woodrat	*Neotoma lepida*			X	
Ferruginous hawk	*Buteo regalis*				X
Flat-tail horned lizard	*Phrynosoma mcallii*			X	X
Fringed myotis	*Myotis thysanodes*				X
Gila monster	*Heloderma suspectum*			X	X
Gila woodpecker	*Melanerpes uropygialis*	Endangered			
Gilded flicker	*Colaptes chrysoides*	Endangered			
Golden eagle	*Aquila chrysaetos*				X
Gray vireo	*Vireo vicinior*			X	X
Inyo Mountains salamander	*Batrachoseps campi*			X	X
Least Bell's vireo	*Vireo bellii pusillus*	Endangered	Endangered		
Le Conte's thrasher	*Toxostoma lecontei*			X	
Little pocket mouse	*Perognathus longimembris*			X	X
Loggerhead shrike	*Lanius ludovicianus*			X	
Long-eared myotis	*Myotis evotis*				X
Long-eared owl	*Asio otus*			X	
Lucy's warbler	*Vermivora luciae*			X	
Merriam's kangaroo rat	*Dipodomys merriami*			X	
Mojave fringe-toed lizard	*Uma scoparia*			X	X
Mountain plover	*Charadrius montanus*			X	
Nelson's antelope squirrel	*Ammospermophilus nelsoni*	Threatened			
Orange-throated whiptail	*Aspidoscelis hyperytha*			X	
Pallid bat	*Antrozous pallidus*			X	X
Palm Springs round-tailed ground squirrel	*Spermophilus tereticaudus chlorus*		Candidate		
Panamint alligator lizard	*Elgaria panamintina*			X	X
Pocketed free-tailed bat	*Nyctinomops femorosaccus*			X	
Quino checkerspot butterfly	*Euphydryas editha quino*		Endangered		
Rosy boa	*Charina trivirgata*				X
Round-tailed ground squirrel	*Spermophilus tereticaudus*			X	
Rufous-crowned sparrow	*Aimophila ruficeps*			X	

Common Name	Scientific Name	CESA	ESA	California Special Concern	BLM Sensitive
Sage sparrow	*Amphispiza belli*			X	
Snowy plover	*Charadrius alexandrinus*		Threatened	X	
Southern rubber boa	*Charina umbratica*			X	
Spotted bat	*Euderma maculatum*			X	X
Summer tanager	*Piranga rubra*			X	
Swainson's hawk	*Buteo swainsoni*	Threatened			
Tehachapi slender salamander	*Batrachoseps stebbinsi*	Threatened			
Townsend's big-eared bat	*Corynorhinus townsendii*			X	
Vermilion flycatcher	*Pyrocephalus rubinus*			X	
Western mastiff bat	*Eumops perotis*			X	X
Western patchnose snake	*Salvadora hexalepis*			X	
Western pond turtle	*Actinemys marmorata*			X	X
Western red bat	*Lasiurus blossevillii*			X	
Western skink	*Eumeces skiltonianus*			X	X
Western small-footed myotis	*Myotis ciliolabrum*				X
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	Endangered	Candidate		
Willow flycatcher	*Empidonax traillii*	Endangered			
Yellow warbler	*Dendroica petechia*			X	
Yellow-breasted chat	*Icteria virens*			X	
Yuma clapper rail	*Rallus longirostris yumanensis*	Threatened	Endangered		
Yuma myotis	*Myotis yumanensis*				X
PLANTS					
Bird-foot checkerbloom	*Sidalcea pedata*	Endangered	Endangered		
Coachella Valley milk-vetch	*Astragalus lentiginosus* var. *coachellae*		Endangered		
Cushenbury buckwheat	*Eriogonum ovalifolium* var. *vineum*		Endangered		
Cushenbury milk-vetch	*Astragalus albens*		Endangered		
Cushenbury oxytheca	*Acanthoscyphus parishii var. goodmaniana*		Endangered		
Cuyamaca larkspur	*Delphinium hesperium* ssp. *cuyamacae*	Rare			
Lane Mountain milk-vetch	*Astragalus jaegerianus*		Endangered		
Mojave tarplant	*Deinandra mohavensis*	Endangered			
Owens Valley checkerbloom	*Sidalcea covillei*	Endangered			
Red Rock tarplant	*Deinandra arida*	Rare			
Santa Ana River woollystar	*Eriastrum densifolium* ssp. *sanctorum*	Endangered	Endangered		
Slender-petaled thelypodiu	*Thelypodium stenopetalum*	Endangered	Endangered		
Southern mountain buckwheat	*Eriogonum kennedyi* var. *austromontanum*		Threatened		
Triple-ribbed milk-vetch	*Astragalus tricarinatus*		Endangered		

2.5.1 Mammals

Table 1 contains significant errors of omission and commission concerning potential covered mammal species. A number of mammal taxa were included in Table 1 on the basis that they are California Mammal Species of Special Concern (MSSC), but without appropriate recognition of subspecific designations and ranges. Note that the MSSC list is currently being revised by a team of mammalogists that are reviewing all available data on the status and distribution of mammals in California (W. Spencer, S. Osborn, et al., In Prep.). The MSSC team has compiled a large database of mammal locality data and is preparing range maps and other information for peer review. A final MSSC list and assessment document is scheduled for completion by May 2011. We recommend finalizing the list of potential covered mammals in late 2010, by which time the draft list of MSSC, along with refined range maps, should be available.

In the meantime, the following species could be ***removed*** from the potential covered species list due to relatively low level of conservation concern within the planning area, or lack of occurrence in the planning area:

- **California pocket mouse** (*Chaetodipus californicus*). This species of pocket mouse is widespread and common in California, mostly in shrublands outside of desert regions. Although one subspecies, *C.c. femoralis*, is a current California MSSC, it is associated with coastal sage scrub outside the current planning area boundaries.
- **Desert woodrat** (*Neotoma lepida*). This is a very common and widespread species throughout California's desert regions. Although one subspecies (*N.l. intermedia*) is a current MSSC, it is associated with coastal sage scrub outside the current planning area boundaries. Moreover, the taxonomy of the *Neotoma lepida* group was recently revised by Patton et al. (2007), which removed a number of former *N. lepida* subspecies, subsuming some within other species of *Neotoma*, including *N.l. intermedia*, which is now *N. bryanti intermedia*. The status of all species and subspecies in the revised taxonomy is currently under review, but at this point it seems unlikely that any *Neotoma* species or subspecies in the DRECP study area will be considered to be of conservation concern.
- **Merriam's kangaroo rat** (*Dipodomys merriami*). This smallest of the kangaroo rat species is common and widespread throughout the deserts, and it is not of conservation concern throughout most of its range. One subspecies of *D. merriami* is federally Endangered (the San Bernardino kangaroo rat, *D.m. parvus*), but it occurs outside the DRECP area, west of the San Bernardino and San Jacinto Mountains. Similarly, another highly restricted and impacted subspecies (the earthquake kangaroo rat, *D. m collinus*) occurs outside the DRECP area in sandy upland valleys in the Peninsular ranges in San Diego County and southernmost Riverside County. Finally, although *D.m. arenivagus* has a highly restricted range that is partially within the plan area, west of the Salton Sea, it is not currently an MSSC and does not appear likely to be added to the MSSC list.
- **Nelson's antelope squirrel** (*Ammospermophilus nelsoni*). This state Threatened species of ground squirrel is found in the San Joaquin Valley, outside the DRECP plan area.
- **Yuma myotis** (*Myotis yumanensis*). Although considered sensitive by the BLM, the Yuma myotis is widely distributed, roosts in a wide variety of natural and anthropogenic structures, and appears well adapted to survival in close proximity to humans. It is considered low-

medium priority for conservation by the Western Bat Working Group. Its potential for listing over the next 30-50 years is minimal.

The following species can be ***retained*** on the potential covered species list for DRECP even though, *at the full species level*, they are quite common and widespread. Nevertheless, *several rare or narrowly distributed subspecies of these species are of conservation concern in the planning area*. *We recommend considering each subspecies individually for inclusion or exclusion from the covered species list*, as detailed here:

- **Little pocket mouse** (*Perognathus longimembris*). This small, silky pocket mouse is associated with fine sandy soils throughout California's deserts and some southern California cismontane (west of the coastal mountains) basins and coastal plains. Although the species as a whole is quite common and widespread, it has a number of rare, endemic subspecies that are of conservation concern, *each of which should be treated separately as a covered species*:
    - ***P.l. bangsi*** (Palm Springs pocket mouse) is restricted to fine sandy soils in the Coachella Valley and southern portions of Joshua Tree National Park, south along either side of the Imperial Valley to about the Mexican border (Ocotillo). It is a current MSSC and will likely remain on the MSSC list due to its highly restricted range and loss of most of its habitat on the Coachella and Imperial Valley floors (Brylski et al. 1998).
    - ***P.l. bombycinus*** (no common name) ranges from Baja California, Mexico, into the southern and eastern Colorado Desert in California (Brylski et al. 1998). It is a current MSSC that is likely to remain on the list due to restricted distribution and habitat loss.
    - ***P.l. brevinasus*** (Los Angeles pocket mouse) is restricted primarily to cismontane basins outside the DRECP plan area; accept where it intergrades with *P.l. bangsi* in the San Gorgonio Pass-Palm Springs area (Brylski et al. 1998). It is a current MSSC and will likely remain on the list due to its highly restricted distribution and loss and fragmentation of populations by urban development.
    - ***P.l. internationalis*** (Jacumba pocket mouse) is found southwest of the Salton Sea and into Baja California, Mexico. Due to restricted range, there is some potential it will become an MSSC, but it is unclear whether it occurs within current DRECP boundaries.
    - ***P.l. salinensis*** (no common name) is known only from within Death Valley National Park, so it is unlikely to be affected by plan actions (J. Patton, personal communication).
    - ***P.l. tularensis*** (no common name) is restricted to the Kern Plateau, probably outside of DRECP boundaries (J. Patton, personal communication).
- **Round-tailed ground squirrel** (*Spermophilus* [now *Xerospermophilus*] *tereticaudus*)[5]. This species is fairly common and widespread in the Colorado and Mojave Deserts south and east of the Mojave River. At the full-species level, it is not of elevated conservation concern.

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[5] A common issue with CNDDB and California's Species of Special Concern lists is that they do not keep up with taxonomic changes. For example, the genus *Spermophilus* was recently split into eight genera based on substantial morphological, genetic, ecological, and behavioral variation (Helgen et al. 2009). Although in this particular case, the change did not affect the conservation status of the taxa in DRECP, in other cases it does, and these differences cannot be ascertained from CNDDB or CWHR data and range maps.

However, the subspecies *S.t. chlorus* (Palm Springs ground squirrel) has a very limited distribution in the Coachella Valley, where much of its sandy habitat has been lost to development. The Palm Springs ground squirrel is an MSSC and a federal Candidate for listing, and is highly likely to remain an MSSC with potential to become listed as Threatened or Endangered. *We therefore recommend retaining X.t. chlorus, but **not** the full species of X. tereticaudus, as a candidate for coverage under DRECP.*

The following species should be ***added*** as potential covered species because they are found in the planning area, are of conservation concern, and could be affected by the plan:

- **Tehachapi pocket mouse** (*Perognathus alticolus inexpectatus*). This MSSC is restricted to a narrow range along the western-most edges of the Mojave Desert and adjacent slopes of the Tehachapi and San Gabriel Mountains. It has only been detected from the vicinity of Tehachapi Pass, west to Mount Pinos, and south to Elizabeth and Quail Lakes, between 1030 and 1830 m elevation. This range corresponds closely with areas of high wind energy potential (NREL wind potential maps).
- **Yellow-eared pocket mouse** (*Perognathus parvus xanthonotus*). Although not currently on the MSSC list[6], this narrow-endemic pocket mouse is BLM sensitive and likely to be added to the MSSC list. It is known from only four localities on the eastern slope of the Tehachapi Mountains at Horse, Sage, Freeman, and Indian Wells canyons, between 1400 and 1615 m elevation. This range coincides with an area of high wind-energy potential.
- **Mohave ground squirrel** (*Spermophilus [Xerospermophilus] mohavensis*). This state-listed Threatened species was clearly an inadvertent omission from the preliminary list of species (Table 1), as it is a key species of concern in areas with high solar development potential in the western Mojave Desert.
- **Mojave River vole** (*Microtus californicus mohavensis*). This subspecies of the California vole is an MSSC. It is restricted to areas along the margins of the Mojave River where water comes to the surface due to shallow water table, in and near Victorville and Oro Grande. Although it is unlikely to be directly impacted by energy developments, any actions that might affect the hydrology of the Mojave River would be detrimental. A *Mictrotus californicus* population also occurs at Harper Lake Marsh about 10-15 miles northwest of Barstow. Although it is unknown whether this is *M.c. mohavensis* or another, less sensitive subspecies, any populations of voles or other species restricted to isolated wetland habitats in the desert may be unique and should be considered sensitive. The advisors recommend avoiding developments that could reduce the water table at Harper Lake or any other desert wetlands.
- **Amargosa River vole** (*Microtus californicus scirpensis*). This subspecies of the California vole is both federally and state-listed as Endangered. It is associated with Olney bulrush (*Scirpus olneyi*) marshes along the Amargosa River, and is found in disjunct populations that may be temporary in nature (Bleich 1998). Although this species is unlikely to be directly

[6] Although Williams (1986) originally included yellow-eared pocket mouse as an MSSC, Brylski et al. (1998) placed it on an MSSC “Watch List" due to lack of sufficient information.

impacted by energy developments, any actions that may affect hydrology of the Amargosa River would be detrimental.

- **Hoary bat** (*Lasiurus cinereus*). Although this species is widely distributed and unlikely to be listed as threatened or endangered in the near future, hoary bats are the most frequently killed species at wind energy developments in North America (Arnett et al. 2008) and have been recorded as fatalities at wind energy facilities within the DRECP (Chatfield et al. 2009). Given the cumulative impacts of massive expansion of utility-scale wind energy development in the United States, combined with low reproductive rates of bats, there is some potential for hoary bats to be added to one or more special status lists within the next 30-50 years.
- **Western yellow bat** (*Lasiurus xanthinus*). This species is currently on the MSSC list and a large proportion of its distribution in California is within the DRECP area. Fatalities of this species have been recorded within the DRECP area (Chatfield et al. 2009).

2.5.2 Birds

The Draft Covered Species List (Table 1) requires modification to reflect the latest listings by the California Department of Fish and Game and the United States Department of Interior, as well as to apply more accurately to relevant subspecies and other infraspecific categories. In many cases the California Bird Species of Special Concern list (hereafter BSSC; Shuford and Gardali 2008) limits the seasonal or infraspecific application of its listings. United States Fish and Wildlife Service (USFWS) listings also need to be updated, resulting in some additions to the covered species list (see below).

Subspecies taxonomy is in a state of flux for North American birds. The most recent formal treatment of subspecies by the American Ornithologists' Union Committee on Classification and Nomenclature was published in 1957 (AOU 1957); more recent formal checklists (e.g., AOU 1998) do not include subspecies, although well-marked infraspecific groups may be annotated. Current trends recognize the utility and convenience of subspecies (Fitzpatrick 2010) and the need for more quantitative diagnoses of subspecies (e.g. Remsen 2010). Without refinement of subspecies treatments, conservation efforts can be confused or even hampered (Haig and D'Elia 2010).

We recommend that the following species be ***removed*** from the list of potentially covered species:

- **Bewick's wren** (*Thryomanes bewickii*). No mainland subspecies in western North America have formal conservation status. The widespread cismontane subspecies *charienturus* occurs in the western margins of the Mojave and Colorado deserts, and the Great Basin subspecies *eremophilus* occurs in the higher elevations of the northeastern Mojave Desert; there are no indications of declines of either taxon on the California deserts.
- **Cactus wren** (*Campylorhynchus brunneicapillus*). Although this species needs to be considered in desert conservation planning, populations in the DRECP area have no formal conservation status. The California BSSC designation applies only to the coastal subspecies *sandiegensis* from southern Orange County through coastal San Diego County (Shuford and Gardali 2008), though the remaining coastal populations north to Los Angeles and Ventura

Counties (considered part of the widespread desert subspecies anthonyi) are similarly imperiled. Widespread *anthonyi* of the Mojave and Colorado Deserts has no formal status.

- **Le Conte's thrasher** (*Toxostoma lecontei*). Although this is an important planning species in the California deserts, the nominate subspecies of the Mojave and Colorado Desert has no formal BSSC status (such status applies only to the San Joaquin Valley population; Shuford and Gardali 2008).
- **Common yellowthroat** (*Geothlypis trichas*). Only the San Francisco Bay subspecies *sinuosa* has BSSC status; breeding populations and widespread migrants on the deserts have no formal or informal conservation status.
- **Rufous-crowned sparrow** (*Aimophila ruficeps*). Only the northern Channel Island endemic subspecies *obscura* has BSSC status. Otherwise this species is west of the deserts, except for small, local populations of the interior subspecies *scottii* in the higher portions of the eastern Mojave Desert, which have no formal status but which should be addressed if its limited habitats undergo potential impact.
- **Sage sparrow** (*Amphispiza belli*). Although cismontane nominate *belli* has shown local declines, it is not present in the deserts. Formal status (ESA Threatened and BSSC) applies only to the endemic subspecies of San Clemente Island. The breeding subspecies in the DRECP planning area is *canescens*; it has no formal status but may be an important indicator species of alkali scrub and other desert scrub habitats.

The following species should be ***retained*** on the list of potentially covered species, although their designations need modification in Table 1:

- **Snowy plover** (*Charadrius alexandrinus*). Delete ESA Threatened designation in Table 1, which only applies to coastal populations (to 50 miles inland, which might border portions of the planning area, e.g. in the Lancaster area); add California BSSC designation (which applies to interior California populations).
- **Willow flycatcher** (*Empidonax traillii*). Add ESA Endangered status, which applies to the subspecies *extimus* ("Southwestern Willow Flycatcher") which breeds along the lower Colorado River and (at least formerly) elsewhere in desert riparian areas.
- **Bendire's thrasher** (*Toxostoma bendirei*). Add California BSSC designation.
- **Yellow warbler** (*Dendroica petechia*). The table should clarify that both the subspecies *sonorana* (lower Colorado River) and *brewsteri* (widely in cismontane California, and locally in desert riparian areas) are listed as California BSSCs and treated in separate accounts in the BSSC publication (Shuford and Gardali 2008).

The following species should be considered for ***addition*** to the list of covered species by virtue of conservation status:

- **Fulvous whistling-duck** (*Dendrocygna bicolor*). California BSSC; breeds (now very rarely) in freshwater areas along and bordering the southern portion of the Salton Sea, and regular but declining as a post-breeding visitor to that area. All Salton Sea bird species are potentially impacted by geothermal and solar energy development and associated transmission lines.

- **Redhead** (*Aythya americana*). California BSSC; breeds locally in desert wetlands, including Piute Ponds on Edwards AFB, wetlands in eastern Kern County, and the Salton Sea.
- **California brown pelican** (*Pelecanus occidentalis californicus*). Although recently de-listed by ESA and CESA, the California brown pelican remains a California Fully Protected Species, and de-listed species still require conservation monitoring and protection. This species is a regular visitor (mainly in summer and fall) to the Salton Sea and has made breeding attempts there. It occurs only casually elsewhere on the California deserts.
- **Least bittern** (*Ixobrychus exilis*). California BSSC (breeding populations); a local breeder in freshwater wetlands on the deserts; more numerous at the Salton Sea and elsewhere in the Imperial Valley and lower Colorado River.
- **Wood stork** (*Mycteria americana*). California BSC. Regular post-breeding visitor from colonies in Mexico to the southern (mainly southeastern) shoreline of the Salton Sea and nearby freshwater lakes.
- **Northern harrier** (*Circus cyaneus*). California BSSC (breeding populations); local breeder in marshes and (after years of high rainfall?) annual growth in the Imperial Valley and Mojave Desert.
- **Peregrine falcon** (*Falco peregrinus*). Although recently de-listed by ESA and CESA, such de-listed species still require conservation monitoring and protection.
- **Lesser sandhill crane** (*Grus canadensis canadensis*). California BSSC; wintering population in the Imperial Valley and probably lower Colorado River
- **Greater sandhill crane** (*Grus canadensis tabida*). California ESA Threatened; small numbers likely winter population in the Imperial Valley.
- **Van Rossem's gull-billed tern** (*Gelochelidon nilotica vanrossemi*). California BSSC; candidate for ESA Threatened/Endangered species status as of June 2010. Breeds at the Salton Sea (mainly southern end); also uses upland and agricultural areas of Imperial Valley for foraging.
- **Elf owl** (*Micrathene whitneyi*). California ESA Endangered. Highly endangered and nearly extirpated from California, with very local breeding populations (most now eliminated) along the lower Colorado River and west to Corn Spring in the Chuckwalla Mountains.
- **Long-eared owl** (*Asio otus*). California BSSC (breeding populations). Local breeder on the California deserts.
- **Short-eared owl** (*Asio flammeus*). California's BSSC (breeding populations). Very localized breeder on the California deserts.
- **Purple martin** (*Progne subis*). California BSSC (breeding populations). Although this species is not known to breed in the desert planning area, some of the few extant breeding colonies in southern California are near the western edge of the deserts (e.g. Tehachapi Mountains, Cajon Pass area, mountains of San Diego County) and foraging birds may utilize the fringes of the deserts and/or be impacted by transmission corridors coming from the deserts.

- **Bank swallow** (*Riparia riparia*). California ESA Threatened. Migrant through the California deserts, with concentrations regularly noted at wetland areas such as Piute Ponds and the Salton Sea. Nests just north of the planning area in the northern Owens Valley.
- **Inyo California towhee** (*Pipilo crissalis eremophilus*). California ESA Endangered; ESA Threatened. It appears that most or all habitat occupied by this subspecies is outside the planning area, but given the potential for shifting or undiscovered populations and slight seasonal movements this taxon should still receive consideration.
- **Large-billed savannah sparrow** (*Passerculus sandwichensis rostratus*). California BSSC. Regular post-breeding visitor to the shoreline of the Salton Sea, especially at the southern end.
- **Grasshopper sparrow** (*Ammodramus savannarum*). California BSSC. Scarce migrant and possibly local breeder on the California desert margins.
- **Tricolored blackbird** (*Agelaius tricolor*). California BSSC and BLM Sensitive Species; potential ESA listing. Important colonies are located in the western Mojave Desert from the western Antelope Valley east to the Victorville/Newberry Springs area; desert agricultural areas and livestock ranches form important wintering habitat.
- **Yellow-headed blackbird** (*Xanthocephalus xanthocephalus*). California BSSC. Breeds locally on the deserts from the Owens Valley and western Antelope Valley south to the Salton Sea and lower Colorado River.
- **Arizona Bell's vireo** (*Vireo bellii arizonae*): CESA Endangered; populations along the lower Colorado River and in riparian washes west of the river north to Inyo County are relevant to the DRECP.

The following species should receive consideration in desert planning by virtue of being listed as USFWS "Birds of Conservation Concern" within the relevant "Bird Conservation Region" (in the case of the Mojave and Sonoran Deserts, BCR #33). Some of these are already on the list of covered species; for those that are not we provide the scientific name.

- Least bittern
- Bald eagle
- Peregrine falcon
- Prairie falcon (*Falco mexicanus*)
- Black rail
- Snowy plover
- Mountain plover
- Whimbrel (*Numenius phaeopus*)
- Long-billed curlew (*Numenius americanus*)
- Marbled Godwit (*Limosa fedoa*)
- Red knot (*Calidris canutus roselaari*)
- Gull-billed tern
- Black skimmer (*Rynchops niger*)

- Yellow-billed cuckoo
- Elf owl
- Burrowing owl
- Costa's hummingbird (*Calypte costae*)
- Gila woodpecker
- Gilded Flicker
- Least Bell's vireo
- Gray vireo
- Bendire's thrasher
- Le Conte's thrasher (*Toxostoma lecontei*)
- Lucy's warbler
- Sonoran yellow warbler
- Black-chinned sparrow (*Spizella atrogularis*)
- Lawrence's goldfinch (*Spinus lawrencei*)

2.5.3 Reptiles and Amphibians

The following species are recommended for ***deletion*** from the list as not occurring in the DRECP planning area or unlikely to be affected by plan actions:

- **Common ensatina**
- **Orange-throated whiptail**
- **Rubber boa**
- **Tehachapi Mountains slender salamander**
- **Western skink**
- **Panamint Mountains alligator lizard.** The advisors believe that this species is outside of the DRECP planning boundary within the Panamint, Inyo, and Argus mountain ranges.
- **Inyo Mountains slender salamander.** The advisors believe that this species is outside of the DRECP planning boundaries within the Inyo Mountains.

The following species are recommended to be ***retained*** on the list because they may occur in the planning area and have restricted distributions, are restricted to special features or other isolated habitats (e.g., sand dunes, wetlands, rock outcrops, riparian zones), or are listed as being of conservation concern. Developments that fragment their habitats, alter ecosystem processes (wind/sand flow to dunes, reduce water infiltration or increase groundwater extraction damaging wetlands), or increase access for collectors will reduce the sustainability of these populations.

- **Western pond turtle.** This species occurs in Afton Canyon and at Camp Cady along the Mojave River and could be adversely affected by any actions affecting the watershed.
- **Arroyo toad.** This species at least formerly occurred in Afton Canyon along the Mojave River. The advisors are unsure whether this population is extant. We recommend surveys or interviews with species experts, and avoiding any actions that could affect the Mojave River watershed.

- **Coachella Valley fringe-toed lizard**
- **Colorado Desert fringe-toed lizard**
- **Mojave fringe-toed lizard**
- **Flat-tailed horned lizard**
- **Desert tortoise**
- **Barefoot gecko**
- **Gila monster**
- **Couch's spadefoot toad**
- **Gilbert's skink**

2.5.4 Fish

A variety of rare, endemic pupfishes (*Cyprinodon* spp.) are found in springs, streams, and swamps in the DRECP plan area. Any activities that affect ground or surface waters may affect these isolated habitats and could adversely affect these unique fishes. We recommend consulting an independent scientific expert on these species (e.g., Don Sada, Desert Research Institute, Reno, Nevada) to determine whether any could be affected by plan actions and should be added as potentially covered species. The plan should thoroughly consider and avoid potential effects of renewable energy projects on surface or ground water hydrology.

2.5.5 Invertebrates

Accounting for and conserving invertebrates, especially arthropods, is difficult but necessary for a successful conservation plan. Although invertebrates comprise more than half the biodiversity in terrestrial ecosystems, most groups of insects and other arthropods are poorly known, with numerous undescribed species (New 1993, 1999, Redak 2000, Wilson 1988). Nevertheless, arthropods provide crucial ecological functions, including pollination, herbivory, and decomposition, that strongly influence the structure and function of natural communities. The advisors noted that arthropods were grossly underrepresented in the proposed list of covered species, with only a single endangered butterfly on the list (Quino checkerspot; *Euphydryas editha quino*)—and that species has not been recorded in the planning area, as it is associated with coastal sage scrub habitat to the west. There are nevertheless many sensitive species of invertebrates in the planning area that should be considered for coverage. For example, Table 2 lists desert insects recently reviewed as candidates for threatened and endangered status (to date USFWS has ruled that there is insufficient evidence to list any of these species). Regardless of their legal status, these species may be at risk and are representative of unique habitats, such as dunes and sand plains. Furthermore, Bunn et al. (2007) listed 28 California-endemic, special status invertebrates in the Mojave Desert and 13 in the Colorado Desert. We recommend a thorough review of available information on the status and distribution of rare and endemic invertebrates in the planning area, including interviews with experts, to assemble a list of invertebrates for consideration as covered species. Appendix C lists individuals having pertinent expertise that should be contacted for input.

Table 2. Desert invertebrates recently considered for threatened and endangered status (Federal Register 71(160) 47765-47771. 2006).

Common Name	Scientific Name	Order
Sand wasp	*Microbembix elegans*	Hymenoptera
Sand wasp	*Stictiella villegasi*	Hymenoptera
Solitary bee	*Perdita algodones*	Hymenoptera
Solitary bee	*Perdita glamis*	Hymenoptera
Vespid wasp	*Euparagian.* sp.	Hymenoptera
Velvet ant	*Dasymutilla nocturna*	Hymenoptera
Velvet ant	*Dasymutilla imperialis*	Hymenoptera
Algodones sand jewel beetle	*Lepismadora algodones*	Coleoptera
Algodones white wax jewel beetle	*Prasinalia imperialis*	Coleoptera
Algodones croton jewel beetle	*Agrilus harenus*	Coleoptera
Hardy's dune beetle	*Anomala hardyorum*	Coleoptera
Scarab beetle	*Cyclocephala wandae*	Coleoptera
Ruth's dune weevil (new subspecies 1)	*Trigonoscuta rothi rothi*	Coleoptera
Ruth's dune weevil (new subspecies 1)	*Trigonoscuta rothi algodones*	Coleoptera
Ruth's dune weevil (new subspecies 1)	*Trigonoscuta rothi imperialis*	Coleoptera
Ruth's dune weevil (new subspecies 1)	*Trigonoscuta rothi punctata*	Coleoptera

After compiling a list of potential invertebrate species of concern, an effort should be made to establish their distributions in the plan area. This could be done once a draft DRECP is developed by holding taxonomic-focused meetings involving individuals listed in Appendix C, and by examining collections and databases from the following museums:

- Entomology Research Museum, University of California, Riverside
- Bohort Entomology Museum, University of California, Davis
- Essig Entomology Museum, University of California, Berkeley
- Natural History Museum of Los Angeles
- California Academy of Sciences
- Natural History Museum of San Diego County

Examination of these collections will likely lead to further examinations of additional private and public collections. The goal should be to establish maps of current and historic distributions of rare invertebrate species. Gaps in distributions should be surveyed. Existing location data for arthropods is biased towards easily accessible roads, such that historical distributions may be misleading.

2.5.6 Plants

Table 1 appears to include only plants protected under the state and federal Endangered Species Acts. A much larger suite of rare plants should be considered as potentially covered species, including all species recognized by the California Native Plant Society's (CNPS) as "1B List" and "List 2" plants (Appendix D–DRECP Recommended Covered Plant Species). The 1B designation identifies plants known to be rare, threatened, or endangered in California and elsewhere. The "List 2" designation identifies plants known to be rare, threatened, or endangered in California but more common elsewhere. Despite List 2's wider distribution, these species are rare in California, and their inclusion as covered species helps to realize the NCCP goal of protecting California's biodiversity. As with the rare vegetation alliances, high priority for conservation should be focused on those rare plants that have a threat ranking of 0.1 (Seriously threatened in California; high degree/immediacy of threat) or 0.2 (Fairly threatened in California; moderate degree/immediacy of threat).

In June 2010, the CNPS Rare Plant Program developed a list of rare, threatened, and endangered desert plants potentially affected by the footprints of wind and solar projects proposed up to that time in the California Desert. This list of high priority "at risk" species includes rare plants with occurrences documented by the California Natural Diversity Data Base that fell within a proposed project footprint and/or within a BLM Solar Energy Study Area (SESA) as of June 2010 (Appendix E). GIS layers used in this analysis include:

- BLM renewable energy project layers
- DFG renewable energy project layers
- RETI renewable energy project layers
- RETI transmission line layers
- RETI substation layer
- BLM SESA layer
- REAT RESA layer

The list of affected species considered at high to moderate risk from renewable energy projects contains 171 taxa, of which 102 are on CNPS List 1B, including 14 federally endangered species, 5 federally threatened species, and 1 federal candidate for listing (also California endangered), and 10 California endangered species. Sixty-nine additional taxa are on CNPS List 2. List 1B plants are considered special-status species by BLM, and both List 1B and List 2 taxa meet the definition of rare under CEQA. Thus, these plants require mitigation under either NEPA and/or CEQA.

Similar to the unusual plant assemblages and rare vegetation alliances, our knowledge of the distribution of rare plants in the California deserts is currently incomplete. For this reason, the advisors recommend that additional season-appropriate surveys conducted throughout the desert regions be incorporated into the database for the DRECP, and recognized and incorporated through the adaptive management strategy.

2.6 Additional Planning Species

The advisors recommend considering whether the list of covered species should be supplemented with additional *planning species* that can assist with meeting plan goals (e.g., because they may serve as easily monitored "indicators" of environmental conditions). Specifically, we propose a method modified from Lambeck (1997), who suggested that conservationists identify groups of species whose vulnerability can be attributed to a common cause, such as loss of habitat area or alteration of a natural disturbance regime. Species in each group can then be ranked in terms of their vulnerability to those threats, and the most vulnerable members may be used as indicators for the group. Often, but not always, such indicator species are listed as threatened or endangered or likely to be listed in the future. This process has been used in California to select focal bird species for seven of the eight habitat-based bird conservation plans, as described by Chase and Geupel (2005). California Partner's in Flight (2009) recently completed a conservation plan for desert birds that should also be consulted.

Lambeck identified four functional categories of focal species. For each group the focal species are those most demanding for the attribute that defines that group and which therefore serve as the "umbrella" species for that group. Together, these species tell us what patterns and processes in the landscape must be sustained in order to sustain biodiversity. Their collective needs define conditions and thresholds—such as patch size, connectivity, fire frequency, etc.—that must be met if the native biota is to be maintained (Lambeck 1997).

- *Area-limited species* have large home ranges, occur at low densities, or otherwise require large areas to maintain viable populations. Examples include large mammals (such as bighorn sheep) and large raptors (such as golden eagle or California condor).
- *Dispersal-limited species* are limited in their dispersal capacity, sensitive to particular movement barriers such as highways or canals, or are vulnerable to mortality when trying to move through human-dominated landscapes. Examples include numerous amphibians and reptiles (e.g., desert tortoise), large-seeded herbaceous plants (Layne locoweed, *Astragalus laynei*), and species sensitive to roadkill (such as desert tortoise).
- *Resource-limited species* require resources that are at least occasionally in critically short supply. Good examples for DRECP include species that rely on wetlands and open water, such as the southern yellow bat (*Lasiurus ega*), which is restricted to unburned palm oases.
- *Process-limited species* are sensitive to details of the disturbance regime (e.g., the frequency, severity, or seasonality of floods or fires) or other manifestations of natural processes, such as hydroperiod, fire-return intervals, or the flow velocity of streams. Examples include species associated with active sand dunes, which relay on wind-transport of sands; perennial plants that require extremely low fire frequency (e.g. blackbrush, *Coleogyne ramosissima,* and Joshua tree; DeFalco et al. 2010); and playa invertebrates, such as fairy shrimp, that require inundation for the completion of their life cycles.

To this list we add one category:

- *Keystone species*, which exert a disproportionately strong influence on community structure or function due to their physical or biological effects on ecosystems and their interactions with other species (Soulé et al. 2003). Examples include top carnivores (like cougar) that may provide top-down regulation of food webs (Soulé and Terborgh 1999). Some keystone species are also known as *ecosystem engineers* because they physically alter the environment to create habitat features used by other species. Examples include burrowing animals (like tortoises, badgers, and kangaroo rats) that provide microhabitats and homes for numerous other species, and harvester ants, which significantly alter soil structure and nutrients, influence desert seed banks, and hence vegetation (DeFalco et al. 2009). Creosote bush (*Larrea tridentata*) can be considered an ecosystem engineer because its long lifespan enables accumulation of eolian sediments around its base, forming coppice mounds that provide habitat for annual plants and serve as substrate for numerous burrowing animals, including desert tortoises and rodents.

We suggest that plan participants review the list of potentially covered species to see whether they adequately represent this range of functional categories for broadly defined natural communities (one approach might be to use vegetation Classes and Subclasses as listed in Appendix B as a basis for defining broad natural communities, but this deserves further consideration and discussion). A table or matrix that categorizes species by functional category and community type could be used for this purpose. For categories or communities not adequately represented by the existing covered species list, consider supplementing the list with additional planning species to ensure that all communities and essential processes are addressed.

Regardless of whether the plan uses this structured approach to adding planning species, we recommend considering the needs of at least the following species in designing the reserve and developing mitigation, management, and monitoring plans, even though these species are not listed or are unlikely to be listed as Threatened or Endangered:

- **American badger** (*Taxidea taxus*)**.** Badgers are uncommon and declining indicators of open habitats in California (Williams 1986, Quinn 2008). They require very large landscapes and are highly sensitive to habitat fragmentation and roadkill (Quinn 2008, Crooks 2002). They are also important keystone species due to their burrowing activities.
- **Golden eagle**. Eagles are protected above and beyond the measures of the Migratory Bird Treaty Act by the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668c), enacted in 1940. However, the wide-ranging Golden Eagle is also a key planning species because of the large individual home range, reliance on healthy populations of native vertebrate prey (particularly lagomorphs, especially *Lepus*), high susceptibility to disturbance by humans at nest sites, and vulnerability to collisions with power lines and wind turbines (Kochert et al. 2002).
- **Joshua tree** (*Yucca brevifolia*). The Joshua tree is widespread in the Mojave Desert where it is susceptible to fire associated with invasive grasses (DeFalco et al. 2010) and climate change (Cole et al. In Press). Both living and dead Joshua trees provide nesting platforms for raptors and passerines, including red-tailed hawks (*Buteo jamaicensis*), golden eagles (*Aquila*

chrysaetos), loggerhead shrikes (*Lanius ludovicianus*), Scott's orioles (*Icterus parisorum*), and Cassin's kingbirds (*Tyrannus vociferans*). They also provide the only cavity spaces over large areas for such species as ladder-backed woodpeckers (*Picoides scalaris*), Northern flickers (*Colaptes auratus*), small owls, and brown-crested flycatchers (*Myiarchus tyrannulus*). Such reptiles as the night lizard (*Xantusia vigilis)*, desert spiny lizard (*Sceloporus magister*), and night snake (*Hypsiglena torquata*) are also closely associated with live or dead Joshua trees. Invertebrates are famously associated with tree yuccas in the obligate mutualism of the yucca moth (*Tegeticula* spp.), and a host of other species feed on all parts of the Joshua tree. Another recently described association of the Joshua tree is the relationship with desert rodents which cache and eat the seeds (Vander Wall et al. 2006, Waitman 2009). Evidence of the sensitivity of Joshua tree distribution to climate change occurs in the fossil record (Cole et al. In Press).

- **Ironwood** (*Olneya tesota*). The ironwood is a keystone species in the Sonoran Desert due to its influence on soil nutrients and the food and cover it provides for a variety of desert biota (Nabhan and Carr 1994). Ironwood provides nesting platforms and cavities for nesting birds, and its dense canopy is utilized by nearly 150 bird species. The ironwood is the last in a phenological series of desert tree legumes to bloom following mesquite and palo verde. The Ironwood provides sustenance to invertebrates and thereby food for migrating and resident birds. In addition, ironwood is one of the longest-living plants in the Sonoran Desert, with individuals living well over 1000 years, so it serves as an extremely long-term component over centuries of extreme drought in providing a micro-habitat with less direct sunlight, lower surface temperatures, more organic matter, higher water availability, and protection from herbivores. Over the lifetime of one tree, more than 230 plant species have been recorded starting their growth within the protective microclimate under ironwood "nurse plants" (Nabhan and Carr 1994). This also creates an optimum wildflower nursery which is foraged by rabbits, bighorn, and other native species. An extraordinary level of biodiversity is created by ironwoods, including many dozens of species of bees, ant colonies, and other insects.

- **Blackbrush** (*Coleogyne ramosissima*). Near monospecific stands of blackbrush occur in the Mojave Desert on old geomorphic surfaces with substantial calcrete in the underlying soil horizons. These stands, typically at intermediate elevations and occasionally with significant populations of Joshua trees, typically have high levels of non-native annuals, notably red brome (*Bromus madritensis* ssp. *rubens*), which provide the fine-fuel loading for wildfire, and blackbrush itself is highly flammable. As a result, a disproportionate number of fires, and particularly ones covering larger areas, occur in this vegetation alliance (Brooks and Esque 2002, Brooks and Matchett 2003, 2006). Recent work on the Nevada Test Site (Esque and Webb, unpublished data) suggests that a large amount of the area occupied by near-monospecific stands of blackbrush are burning, and previous work has suggested that natural recovery of blackbrush stands may require millennia (Webb et al. 2009b). We believe there is a pressing need to preserve the remaining area of this unique vegetation alliance from human-induced ignition.

- **Spiny hopsage** (*Grayia spinosa*). The presence of this species is thought by some indicative of suitable habitat for Mojave groundsquirrel, although it is uncertain whether the species itself contributes to habitat quality for this animal.

The following bird species were selected by CalPIF (2009) as desert focal species because they use desert vegetation as their primary breeding habitat, they are great enough in abundance to provide adequate sample sizes for statistical comparisons, and they have experienced reductions from their historical breeding range. They should therefore be considered as potential planning species for DRECP.

- **Costa's hummingbird** (*Calypte costae*).
- **Ladder-backed woodpecker** (*Picoides scalaris*).
- **Ash-throated flycatcher** (*Myiarchus cinerascens*). Although this species is common and widespread, it is an obligate cavity nester and therefore can serves as a surrogate for assessing nest site availability for desert cavity-nesting species.
- **Verdin** (*Auriparus flaviceps*).
- **Black-tailed gnatcatcher** (*Polioptila melanura*).
- **Le Conte's thrasher** (*Toxostoma lecontei*).
- **Crissal thrasher** (*Toxostoma crissale*). This species is of interest because it occupies two very different desert woodland types – mesquite and riparian in the lower deserts, and pinyon-juniper woodland in the higher areas of the eastern Mojave Desert.
- **Phainopepla** (*Phainopepla nitens*). Phainopeplas provide important ecological services (dispersal of mistletoe seeds).
- **Black-throated sparrow** (*Amphispiza bilineata*).
- **Scott's oriole** (*Icterus parisorum*). This is a focal species in the analysis of desert woodlands (Joshua tree and pinyon-juniper).

The following bird species may also require attention in conservation planning and project siting analysis for various reasons:

- **Common raven** (*Corvus corax*). In recent years, raven populations have increased enormously in the Mojave Desert due to human activities that provide food and habitat structure (Boarman 1993, Boarman and Berry 1995). As subsidized predators, ravens can do significant harm to populations of sensitive species, including desert tortoise and various lizards and other small vertebrates. CalPIF (2009) designated the common raven as a planning species because it is widespread in desert habitats, is in part a human commensal, thrives in developed and disturbed lands and where nest sites are provided by transmission lines and other human-built structures, and is a known and significant subsidized predator on a variety of sensitive species.
- **Harris's hawk** (*Parabuteo unicinctus*). Very localized resident (though largely extirpated) along the lower Colorado River and occasionally in desert woodlands farther west.
- **Greater roadrunner** (*Geococcyx californianus*). Widespread in the deserts, but of interest because severe declines of cismontane populations indicate a lack of compatibility with large-scale development (in addition to its iconic status as a quintessential desert bird).

- **Brown-crested flycatcher** (*Myiarchus tyrannulus*). Very localized secondary cavity nester in desert riparian habitats (formerly listed as a California BSSC).
- **Scrub jay** (*Aphelocoma californica*). Two subspecies are localized on the California deserts. *A.c. cana* on Eagle Mountain in Riverside County, and *A.c. nevadae* [alternatively called *A.c. woodhousei*, though most authors restrict that name to a more easterly population] in the montane woodlands of the eastern Mojave Desert.
- **Pinyon jay** (*Gymnorhinus gymnorhinus*). A localized pinyon-pine specialist found in some of the higher ranges of the eastern Mojave and along the western fringes of the deserts in the Sierra Nevada, San Bernardino Mountains, and San Jacinto Mountains.
- **Juniper titmouse** (*Baeolophus ridgwayi*). Localized resident of pinyon-juniper woodlands in the eastern Mojave Desert.
- **Northern cardinal** (*Cardinalis cardinalis*). Rare visitor to the lower Colorado River, occasionally breeding. Some or most records elsewhere on the deserts may pertain to escapees.

2.7 Special Features

A wide variety of geological and hydrological features provide habitat attributes essential to numerous desert species and communities. The following features should be mapped to the degree feasible and considered in conservation design and project siting.

- **Desert pavement**. Desert pavement is a dense, continuous cover of pebbles and rock fragments resulting from erosional processes over very long periods. They serve to armor underlying soils from wind erosion (Miller et al. 2009). Breaking of pavements by scraping or other mechanical forces can increase erosion and wind-blown dusts. Development should avoid disturbance to desert pavements. The distribution of desert pavements can be obtained from surficial geologic maps, generally published at 1:100,000 scale and available on the internet (e.g., for near Blythe, California, http://ngmdb.usgs.gov/Prodesc/proddesc_76909.htm).
- **Playas**. Playas are alkaline flats or basins where surface water collects following runoff and either evaporates or infiltrates into the subsurface. The interior portions of playas can develop physical crusts that make their silt and clay soils relatively stable to wind erosion if not mechanically disturbed. Playa margins, in contrast, can be sources for windblown dust, particularly if physical and biological crusts are disrupted. Playa dusts also contain concentrations of toxic substances, such as arsenic and other heavy metals (Chaffee and Berry 2006). Maintenance of crusts and perennial vegetation will reduce dust emissions. Energy projects should avoid use of playa surfaces and only use playa aprons if surface disruption is minimal and vegetation cover is minimally disturbed.
- **Alluvial fans and bajadas**. Alluvial fans are fan-shaped deposits formed where fast-flowing streams exit canyons onto flatter plains. The coalescing of adjacent alluvial fans into a single apron of sloping deposits is called a bajada. Sediments are deposited on alluvial fans by two fluvial processes, streamflow flooding and debris flow. The slowing of floodwaters as they enter and spread over alluvial fans creates gradients of particle sizes, with larger rocks generally deposited near the top of the fan and progressively smaller rocks and soil particles farther down, concluding in fine silts and clays where the fan may terminate in a playa.

Debris flow can transport large particles long distances downslope from mountain fronts onto alluvial fans and create a complex spatial arrangement of particles. Both processes create physical gradients of particles and soils that provide spatially varied habitats for different types of plants and animals. Groundwater recharge is extremely rare in the deserts, and typically only occurs at the top of fans near major mountain fronts or, to a lesser extent, along ephemeral washes that extend downslope through the fans. Disruption of these ephemeral washes, and particularly blockages of washes upslope of mountain fronts, will negatively influence groundwater recharge and should be avoided. Finally, sheetwash, particularly following summer thunderstorms, creates habitat-sustaining runon on low-slope settings, sustaining desert ecosystems that otherwise would be more xeric. Disruption of sheetflow systems using diversion berms or channelization should be avoided.

- **Biological soil crusts**. Biological soil crusts are soil surface communities of mosses, fungi, algae, and bacteria that are particularly well developed where winter rains dominate. They provide armoring of the soil surface, reduce erosion from water and wind, and create a roughened surface where seeds may be caught. They also help with varied biogeochemical cycling, decomposition, and fixation of nitrogen, which can be a limiting nutrient during wet years. Removal or disruption of biological soil crusts can increase dust production. It can also limit primary production, especially of desert annuals, an important food source for many desert animals. Siting of developments should avoid disruption of biological soil crusts, which may require millennia to recover (Webb et al. 2009b).

- **Cliffs.** Vertical cliff environments provide uniquely harsh thermal and hydraulic environments that tend to have reduced but unique vegetation types. Due to their harshness, such sites are difficult to rehabilitate following disturbance. The base of these vertical habitats provide unique run-on habitats that may be particularly species rich, and production can be quite high depending on soil conditions; however, intense recreational use (e.g., rock climbing) can severely damage these areas. Cliffs provides nest sites and perches for raptor, vultures, and passerine birds, and roost sites for multiple species of bats. Siting renewable energy facilities or transmission lines near cliffs may increase risks to these species. The chuckwalla lizard (*Ater obesus*) and the lyre snake (*Trimorphodon bisctatus*) are also found almost exclusively in this and nearby boulder-rich habitats.

- **Caves and mines**. Caves and mines can be important aggregation sites for several species of bats recommended for coverage (e.g., *Antrozous pallidus, Corynorhinus townsendii*, *Myotis occultus*, and *M. velifer*). Although renewable energy developments are unlikely to directly disturb cave and mine habitat, siting wind turbines near caves or mines may increase mortality risks for these species. In addition, renewable energy components close to caves or mines may disrupt microclimate conditions or entry/exit routes of bats. Due to sensitivities about publicly revealing the locations of bat caves and mines, we recommend consulting the California Bat Conservation Plan (currently in preparation) and experts in desert bat conservation (e.g., Dr. Pat Brown-Berry) for information on how best to map or use information on bat caves and mines,.

- **Gypsum-rich soils**. These soils contain high quantities of the mineral gypsum and tend to be harsh environments for desert plants. Those plants that can survive on these conditions tend to speciate rapidly and thus, gypsum soil types often support rare, endemic plant communities.

- **Riparian channels and washes**. Two types of riparian ecosystems occur in the California deserts. Obligate riparian systems occur along perennial or intermittent streams with shallow groundwater, particularly in alluvial aquifers where a shallow confinement layer or a fault forces water to or near the surface, such as occurs along the Mojave and Amargosa rivers. Xeroriparian systems are more common and occur along large wash systems that have periodic runoff to sustain episodic channel recharge and allow growth of facultative riparian species—notably leguminous trees such as mesquite (*Prosopis glandulosa)*, palo verde *(Parkinsonia* sp.*)* and smoketree (*Psorothamnus spinosus)*. Both types of riparian systems provide high-value wildlife habitat with more abundant food, cover, and other resources than other desert communities. Riparian ecosystems are also naturally resilient, provide linear habitat connectivity, link aquatic and terrestrial ecosystems, and create thermal refugia for wildlife—all characteristics that can contribute to ecological adaptation to climate change (Seavy et al. 2009). Disruption of riparian channels and washes should be strictly avoided by renewable energy developments and associated roads, etc.
- **Seeps, springs, and pools**. All surface waters and shallow ground waters are essential resources for innumerable species in the deserts. Water is a limiting resource for nearly all desert species, and DRECP should avoid any actions that can directly or indirectly affect these resources via changes in ground or surface water hydrology.
- **Sand dunes.** Sand dunes are part of the larger eolian systems of the California deserts that may be either fossil (formed during a different climatic regime), stabilized, or active. All eolian systems were created by a wind system that entrains sediments typically deposited by streamflow, winnows out the fine-grained material and transports it long distances as dust, and transports sand-sized particles that accumulate into dunes. Some eolian systems accumulate sediments as a result of a shifting wind field; this is the typical reason for the formation of star dunes such as the Dumont and Eureka dunes in the northeastern Mojave Desert. Other eolian systems respond to a unidirectional but divergent wind field that results in directional eolian transport and deposition of sands in barcan or linear dunefields, such as those in the Coachella Valley. Sand dunes sustain an inordinately large number of rare, endemic species, particularly on their margins. Developments should avoid eolian surfaces and disruption of eolian-transport areas.

2.8 Ecological Processes

2.8.1 Geomorphology and Hydrology

Geomorphology of the California deserts has a controlling influence on local- and watershed-scale hydrology, primary production of desert vegetation, stabilization against wind erosion and blowing dust, and the habitat usage of animals. The characteristics of desert soils and other geomorphic surfaces develop over millennia, and disturbances to these important characteristics can have ecological ramifications that last indefinitely. Moreover, some geomorphic surfaces, particularly those bearing desert pavements, formed in past climatic regimes and cannot recover following disturbances under today's climate.

Geomorphic systems in the California deserts are unique in North America because the Basin and Range in this region is more tectonically active than areas to the north or east, and the basins generally are closed (unlike those to the east which drain to river systems). Rainfall seasonality and intensity varies with elevation and in both north-south and east-west gradients, with the highest annual precipitation in northern areas at higher elevation and the highest proportion of summer rainfall in the eastern and southeastern areas. Desert pavements are more common in the central and eastern portions of the California deserts than in the western Mojave.

Geomorphic surfaces are mapped according to the characteristics and processes of landforms, whether they are sand dunes, colluvial[7] slopes, alluvial fans, ephemeral channels, or playas, and the deposits are the near-surface materials associated with those landforms (Miller et al. 2009). Alluvial fans cover the largest area of concern to solar installations, while mountains are generally the sites for wind turbines. The hydrology of desert mountains is complicated because thin veneers of colluvium underlain by variously weathered bedrock create a complicated flow system for precipitation, which may infiltrate into surficial materials and reach groundwater systems or runoff into ephemeral channels that exit mountain fronts and reach alluvial fans. Mountain front recharge is thought to be the primary means of replenishing groundwater systems that underlie all valleys in the California deserts.

Soil characteristics as influenced by geomorphic surfaces are critical to understanding ecosystem function in North American deserts (McAuliffe 1994, Smith et al. 1995, Stevenson et al. 2009). Soils provide the foundation for terrestrial ecosystems, and small differences in soil properties can have large effects on water-holding capacity and nutrient availability (Comstock and Ehleringer 1992, McAuliffe 2003) which affects plant communities and, in turn, animals communities. Downslope from mountain fronts, depositional surfaces (alluvial fans and other landforms collectively called piedmonts) accumulate sediment eroded from the mountains over geologic time. Most alluvial systems in the California deserts terminate in closed basins known as playas, and some of these are connected via overflow systems that developed during the Pleistocene or earlier in geologic time. Playa margins can, in certain cases, have marginal depositional areas where most of the sediment transported in ephemeral channels is deposited prior to water entering the playa. Sand dunes, sand sheets, and alluvial fans are associated with alluvial depositional areas, generally wide, low-slope areas that include playas and depositional plains (Griffiths et al. 2002).

Plant community composition and primary production vary on piedmonts with characteristics of geologic deposits in addition to elevation and precipitation. Surficial geologic deposits vary in soil particle-size distribution, bulk density, and horizonation of the soil. The particle-size distribution of soils determines water-holding capacity: coarse-grained soils have low water-holding capacity and high infiltration rates, while finer-grained soils, particularly those ringing playas with higher silt/clay content, have high-water holding capacities, low infiltration rates, and particles that can bind nutrients. The particle-size distribution generally decreases downslope from mountain fronts to playa termination in response to channel incision and alluvial fan slope (Blair and McPherson 1994). A wide range of geomorphic features and distinctly different soil characteristics can therefore co-occur in close proximity (McFadden and Knuepfer 1990) increasing the diversity of plant and animal communities on piedmonts.

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[7] Materials transported by mast wasting processes, such as landslides and rockfalls.

The low rates of weathering and soil formation in deserts is caused by low precipitation, with lower relative importance of parent material and vegetation (Jenny 1941). Pedogenesis, or soil formation processes, creates soil layers formed from a combination of weathering of deposits in place, eolian deposition of sediment, and rainwater transport of various chemicals (Pavich and Chadwick 2003). Soil characteristics depend on the physical and chemical properties of the deposited sediments that have weathered in place as well as the characteristics of incoming dust. Surface roughness, which is affected by numerous factors, including surface age and the presence of physical or biological soil crusts, can affect the capture and retention of dust particles, organic material (including seeds), and nutrient status.

Organisms interact with soils through bioturbation, in which plant root growth and the burrowing activities of animals alter soil layering, organic material, and nutrient availability (Belnap et al. 2008). Coppice mounds beneath *Larrea tridentata* (creosote bush)—mounds of typically fine-grained sediments mostly from eolian deposition—are common sites for rodent burrows (Titus et al. 2002). Mounds associated with harvester ant colonies are a mix of surface and subsurface soil and large amounts of organic matter collected by the ants. Desert tortoises, larger mammals, lizards, and snakes all utilize burrows, affecting soil texture and chemistry. Varying soil properties affect desert fauna, which prefer specific soil depths and textures for their burrows (Hafner 1977, Whitford 2002). For example, tortoises tend not to dig burrows in sandy soils because they easily collapse.

2.8.2 Eolian Processes and Dustfall

Movement of soil particles (sand, silt and clay) by wind is one of the dominant processes in dryland environments (Breshears et al. 2003). Soil movement affects ecosystem function by altering soil texture, depth, and chemistry, which can strongly affect plant and animal communities. Alteration of natural soil movement processes by construction or other human effects can have long-lasting impacts that reach far beyond the footprint of the project—for example by increasing atmospheric dusts or by disrupting eolian processes that maintain sand dune communities.

Although there are some soil surface types that are inherently unstable (e.g., playa margins, dry wash bottoms), contrary to common belief, most desert surfaces are very stable and produce little sediment in the absence of disturbance (Marticorena et al. 1997). Natural armoring of the soil surface is provided by rocks, physical and biological soil crusts, plants, and plant litter (van Donk et al. 2003). Construction that disturbs these features can greatly increase soil movements and deposition of soil particles in other locations. Loss of soil via wind erosion leaves behind a coarser textured soil with lower fertility and water-holding capacity. Fine particles (silt and clay) can move great distances on the wind, even around the globe, and degrade air quality and visibility. Deposition of dusts can alter soil fertility and water-holding capacity and therefore plant community composition (Reynolds et al. 2001) often favoring non-native annual grasses (Miller et al. 2006). Dust accumulation on leaves and stems of desert plants can reduce physiological performance, plant growth and seedling establishment (Sharifi et al. 1997, 1999, D.R. Sandquist, pers. comm.). Fine soil particles can also transport and deposit toxic elements, such as mercury and arsenic, onto plants and watersheds (Chaffee and Berry 2006). Sources of such toxicants include mines, mine waste, roads, and other disturbed areas, as well as playas.

Because sand grains are larger, they tend not to travel so far as the silts and clays that comprise dust. Input of sand onto existing soil surfaces increases water infiltration, dilutes nutrient concentrations, reduces soil surface stability, and restricts the ability of the soils to hold nutrients and water (Breshears et al. 2003). Sand deposition can also bury plants and change which animal species can effectively burrow or live in the area. Wind-blown sands can also break up the physical crusting that stabilizes finer soils and dislodge the fine particles to increase dust flow.

2.8.3 Ecological Range Shifts

It is important that DRECP planners recognize that species' ranges are dynamic and that reliance on static range maps can be misleading. Species' populations naturally fluctuate and shift on the landscape over time due to natural and anthropogenically affected climatic shifts, species interactions, and stochastic population processes. Absence of species occurrences from particular areas or periods should not be considered a permanent condition (except in cases of irreversible habitat conversion), and DRECP should strive for a conservation design that accommodates community and species requirements today and in the future, especially considering likely shifts due to climate change.

In geologic time, North American deserts are relatively young, with their current distributions dating from the late Quaternary (Axelrod 1979). The late Pleistocene through late Holocene warmer-drier climate corresponds with the formation, accumulation and current distribution of sand dunes across western North America (Norris and Norris 1961, Wintle et al. 1994). The species associations that comprise communities and community distributions are therefore recent and likely still in flux. Additionally, species may be expected to experience shifts in their populations due to meta-population dynamics or seasonal changes in their distribution and abundance.

However, these natural fluctuations in the distributions and abundance of desert organisms may be exacerbated by climate change. The southern California deserts are likely to experience a greater shift from current climate means than any North American site south of the Arctic Circle (Kerr 2008). Although changes in precipitation are less certain than those in temperature, there may be increased droughts in the future, and droughts are major forcing functions in desert ecosystems (Hereford et al. 2006). As climate changes there may be areas with "novel climate conditions" that never previously existed within the DRECP. It is difficult to know how desert organisms will respond to such novel climate conditions. Some organisms may shift to track preferred climatic conditions, but others may need to adapt in place to changing conditions—or go extinct—for example for those species that require particular geological substrates or features that will not move. In the future we can expect new associations or communities of species than we see today (Stralberg et al. 2009). Conservation designs based on a concept of ecological stasis, either with respect to species distributions or community associations, are therefore doomed to fail in the long term.

All of this argues strongly for a conservation design that accommodates a changing climatological and ecological landscape by avoiding further fragmentation of the desert landscape, and hence providing maximum potential for species to track their preferred habitat-climate envelopes as conditions change. However, the reality is that our deserts have already experienced a large amount of fragmentation from roads, cities, canals, military bases, and other developments. Alternative energy development could further contribute to this landscape fragmentation. Maintaining or improving landscape-level linkages that meet the niche requirements of all covered communities and species should be a key focus of DRECP. Section 4.2 of this report provides detailed recommendations for a robust, interconnected reserve system.

2.8.4 Wildlife Movement and Population Connectivity

Sustaining and enhancing habitat connectivity in the face of energy development, urban sprawl, transportation improvements, off-road vehicle use, climate change, and other stressors is a major conservation concern in California's deserts (Spencer et al. 2010). Populations of many of the region's rare and endemic species—such as the desert tortoise, Mohave ground squirrel, and desert bighorn sheep—are becoming increasingly isolated from one another, leading to decreased genetic diversity and risk of extirpations (Hagerty et al. in review, Epps et al. 2007, Hagerty and Tracy 2010). To counter these effects, various analyses have been recently completed or are underway to identify areas in need of conservation and active management to maintain and improve habitat connectivity and wildlife movement potential. The following references should be consulted by DRECP and used to help site renewable energy developments and conservation actions: the California Essential Habitat Connectivity Project (Spencer et al. 2010), the California Desert Connectivity Project (Penrod et al., in preparation), the South Coast Missing Linkages Project (Beier et al. 2006, South Coast Wildlands 2008), and likely bighorn sheep movement corridors (Epps et al. 2007). Section 4.2.8 provides specific recommendations for incorporating results of these projects and ensuring adequate connectivity in the DRECP reserve design process.

2.9 Environmental Gradients

The advisors recommend careful consideration of how environmental gradients can be used in modeling species distributions, understanding important ecological processes, and guiding conservation design. Environmental gradients are graded spatial variations in some aspect of the physical environment, such as changes in temperature and precipitation with elevation or latitude, ground-water depth with distance from a stream or mountain front, or soil particle size and depth with position along an alluvial slope (see Section 2.8). Many organisms naturally distribute themselves in communities relative to such gradients, and preserving broad, intact gradients may help facilitate adaptation to climate change. For example, some species may adjust to a changing climate by shifting upslope to remain within their preferred niches based on temperature and precipitation gradients (Tingley et al. 2009). Because elevation gradients encompass multiple microclimates within a relatively small area or distance, vagile organisms can potentially shift more quickly in steep areas relative to flatter areas (Loarie et al. 2009), and biotic responses to climate change may be mediated by spatial heterogeneity in the landscape (Ackerly et al. 2010). Elevation and other gradients should be preserved with minimal fragmentation to accommodate potential range shifts. Conservation areas on flatter terrain, or on broad, homogeneous landscapes with little variation in conditions, should be connected to more heterogeneous or topographically diverse areas that provide a greater variety of conditions for species to select from under future climate conditions.

2.10 Covered Actions

This section briefly summarizes some potential impacts of renewable energy developments on covered species and communities based on our observations as ecologists. This is not a comprehensive review of all potential impacts, because the science advisors are not experts in the design, construction, or operation of energy facilities. We therefore recommend a more thorough and quantitative review of impacts from alternative energy facilities and appurtenances that builds on our initial overview. This comprehensive review should involve individuals with pertinent scientific and engineering expertise concerning the nature of the various technologies and their specific impacts (e.g., experts at the National Renewable Energy Lab [NREL] or other independent and objective experts).

The primary focus of this overview is the potential ecological impacts of large-scale solar and wind energy projects and associated roads and transmission lines. Our review of geothermal energy impacts is more cursory, and we do not specifically discuss the nature of impacts of RPS biomass projects. Some impacts are likely similar among all technologies (e.g., energy transmission from production sites and disturbance of habitat and wildlife during construction). However, different technologies will differ in the nature, extent, and timing of their impacts and therefore will require different siting criteria and different types of monitoring and mitigation. The plan should address at least the following topics with respect to the different technologies in assessing impacts to covered resources, siting of facilities, and mitigation and best management practices for construction and operations.

- Ground disturbance and associated changes in habitat value, erosion, hydrology, etc., probably represents the single greatest impact of renewable energy development, and the amount and distribution of surface disturbance will vary tremendously between different types of energy development. The plan should consider, for example, the relative effects of a single, large, contiguous footprint versus dispersed small footprints in different contexts. It should also recognize that the impacts of developments on desert ecology and covered species can extend well beyond development footprints due to effects on hydrology, eolian processes, and other factors reviewed in Section 2.8.
- If energy facilities are fenced (e.g., for security purposes) they are likely to become barriers to movement for many species. However, fencing may also protect animals from entrapment in degraded, denuded, or dangerous areas.
- Renewable energy facilities and associated utility roads may expand the influence of cities, towns and settlements and provide additional human access to remote desert areas. Different technologies are likely to vary in the amount and distribution patterns of new roads, which increase habitat fragmentation along with a wide variety of direct and indirect adverse effects to desert ecosystems.
- Construction and operation of facilities may require water for cooling, cleaning of equipment, dust control on roads or during construction, etc. The total amount of water required, and sources of this water, should be thoroughly evaluated for each type of facility, with a goal of strictly minimizing total water use over the life of a project.

- Cables and other linear structures may be buried or above ground. Buried cables will create greater ground disturbance and may disrupt sensitive hydrologies. Aerial cables will disturb the ground for towers, may increase bird fatalities from collisions, introduce perching structures, and increase predation by subsidized predators, such as ravens.
- Renewable energy facilities can have direct effects on wildlife behavior, reproduction, and mortality due to attraction to or avoidance of structures. For example, some species may be attracted to the newly created shade of solar projects, and birds and bats may be attracted to towers or other tall structures. Polarized light reflected from photovoltaic panels creates "ecological traps" for species that mistake the panels for water (Horvath et al. 2010); some birds and insects may be killed by concentrated heat at solar thermal facilities; and many birds and bats are killed by wind turbines (Arnett et al. 2008, Smallwood and Karas 2009).

Table 3 suggests one approach for categorizing differences among technologies in these types of impacts. This approach should be evaluated and completed by DRECP participants, scientists, and engineers having relevant expertise. The following sections elaborate on some of these issues for different types of facilities.

Table 3. A sample approach for categorizing the nature of impacts from alternative development types to guide planning and analysis. This table is tentative and incomplete, and intended only as a sample framework that should be refined and expanded on with input from scientists and engineers more familiar with the impacts of the various technologies.

Criteria	Concentrating Solar	Solar Photovoltaic	Geothermal	Wind
Total Project Area	Low	Low	?	High
Technology Footprint	Contiguous Area	?	?	Highly Dispersed
Surface Disturbance	High	High	?	Low
Road Density	Low	?	?	High
Within-site Transmission Cables	Few	?		Many
Water Use	High	Medium	High	None
Indirect Impacts on Wildlife	Avoidance or Attraction	?	?	Avoidance or Attraction
Direct Impacts on Wildlife	Insects and a few birds killed by heating?	?	?	Collision mortality of bats and birds (insects?)

2.10.1 Roads

Most renewable energy facilities require access roads, which have a wide array of adverse effects on desert resources:

- Increased access by humans may increase disease incidence in wild tortoise populations via more widespread release of captive desert tortoises carrying infectious diseases (e.g., mycoplasmosis, herpesvirus) (Johnson et al. 2006). Captive tortoises are commonly released in the desert (Murphy et al. 2007) and a recent study in the central Mojave Desert found that wild tortoises with mycoplasmosis were more likely to occur near offices, facilities, urbanized areas and paved roads than in remote areas (Berry et al. 2006).
- Some access roads may need to be regularly graded as maintenance. This often produces berms or deeply incised road beds with steep walls that can entrap animals like desert tortoises and cause death by hyperthermia, increased predation, roadkill, or illegal collecting by humans.
- Access roads (especially those associated with transmission lines) provide food and subsidies for avian and mammalian predators. Subsidized predators (e.g., ravens) use the transmission line towers for nesting, perching, and searching for live prey (tortoises, lizards, other birds and their nests). Prey crossing roads are highly visible to predators, and roadkills provide additional food for subsidized predators.
- Access roads provide sources for invasion and establishment of alien plants along and outward from verges and in disturbed areas associated with power towers and transmission lines. One of the more important factors in alien species richness and biomass of *Erodium cicutarium* is density of dirt roads (Brooks and Berry 2006).
- Recreationists and others use utility access roads for numerous types of activities that can negatively affect vegetation and animals living on adjacent lands. For example, trash and illegal dumping occur along roads, attracting subsidized predators.
- Roads alter the surface hydrology (ephemeral stream channels) which alters vegetation species distributions.

Section 4.3 provides guidance for siting, designing, and implementing actions to mitigate the effects of roads and other barriers to wildlife movement

2.10.2 Transmission Lines

Exhibit C of the DRECP Planning Agreement lists the following sorts of covered actions concerning energy transmission: new foundation, delivery, and connector transmission lines required for accessing renewable energy; transmission upgrades; new transmission lines to connect renewable energy projects to the grid; tower or pole replacements; and substations and switchyards. We assume it will also cover new roads, road improvements or other surface disturbances necessary to access new or existing transmission lines and facilities for construction or maintenance.

We emphasize that even though the development footprints of transmission poles and towers are not large, that some desert vegetation can be retained within transmission rights-of-way (ROW), and that some wildlife may live in transmission ROWs, the impacts of transmission lines are not as benign to desert resources as sometimes believed. For example, ravens were once rare in the deserts but have become much more common due, in part, to use of transmission structures for perching, roosting, and nesting. Ravens are attracted to developments, dirt and paved roads, water sources, transmission line structures and human habitations (Boarman 1993, 2003; Boarman and Berry 1995; Knight et al. 1993; Kristan and Boarman 2003). Ravens reduce tortoise populations by preying on young tortoises. Tortoises are also killed by vehicles when crossing the transmission line roads, buried by road graders when utility roads are being maintained, and die from overheating when caught between the berms of transmission line roads (K.H. Berry, personal observations). During 2008-2009, ravens attacked adult tortoises in the Central Mojave Desert (A.P. Woodman, personal communication).

Disturbances from construction of new powerlines may also contribute to the invasion, establishment and dominance of alien plants in the Mojave Desert via soil disturbance and transport of seeds by vehicles (summarized in Brooks and Berry 2006, Brooks and Lair 2009).

2.10.3 Solar Projects

The DRECP is to cover both photovoltaic (PV) and thermal concentrating solar projects, including construction of new facilities and substations, expansions or upgrades to existing facilities, and all project related facilities, including roads, utility connects, transmission, water, and gas lines, etc. The greatest impacts to ecological resources, depending largely on siting, are likely to be the direct removal, degradation, and fragmentation of natural communities and habitat and populations of desert species. Because utility-scale solar developments are very land intensive, direct loss of habitat could potentially be highly significant, unless developments can be sited in already disturbed and degraded lands, such as brownfields, former agricultural lands, or previously graded lands. Nevertheless, as discussed in Section 2.8—and regardless of where they are sited—the ecological effects of projects that disturb desert soils can extend far beyond the areal footprint of the development itself due to downslope effects on hydrology and downwind effects on eolian processes, among other effects. Such offsite effects must be accounted for in the siting, design, construction, mitigation, and monitoring of solar energy developments.

Indirect effects of utility-scale solar may be very significant, but to our knowledge they are poorly studied. Indirect effects may include increased light pollution (which can adversely affect nocturnal species); increased dust and sand generation (and potential for toxic chemical deposition, etc.; see Section 2.8); use of water for dust control, cleaning, cooling, or other operations (potentially depleting ground water sources that sustain scarce and essential wetland and water sources for desert ecosystems) ; and changes to local and downslope hydrology (with associated effects to plant and animal communities).

Solar developments may also have significant direct effects on the behavior, reproduction, and mortality of wildlife species. For example, solar panels create a new source of polarized light pollution that can confuse animals that use polarized light for orientation or behavioral cues. Insects that breed over and deposit eggs in water bodies have been shown to be more attracted to the strongly polarized light reflections off of solar panels than they are to water. This creates an "ecological trap" for such species, resulting in reproductive failure and direct mortality (Horvath et al. 2010). Birds that are attracted to water sources may also be adversely affected[8]. Moreover, the advisors are concerned that thermal concentrating facilities may kill birds and insects directly via thermal stress.

One peer reviewer of this report raised the issue of elevated local or regional temperatures in the vicinity of large-scale solar developments as a potentially significant adverse effect. The advisors are not aware of any studies of local climate effects of large-scale solar projects, and therefore do not know how significant such impacts might be on desert ecology. We therefore recommend further research on this issue, and certainly monitoring of local climate effects as part of the Adaptive Management and Monitoring Program (Section 6).

2.10.4 Wind Projects

According to the DRECP Planning Agreement, the following types of actions are to be covered: installation of anemometers, new turbine installation, expansion of existing wind projects, upgrades to existing facilities, and project-related facilities like roads, and transmission, water, and gas lines. Although the development footprint of wind towers is relatively small (e.g., compared to solar developments), numerous birds and bats are killed by turbine strikes (Arnett et al. 2008), and wind developments have the potential for significant, regional population effects on some species. Turbine towers can also be used for perching and nesting by raptors and thus may elevate predation levels on nearby prey species.

The California condor is an endangered species that has been reestablished in the Tehachapi Mountains and other California mountain ranges. Populations are expanding in the vicinity of existing wind farms in the Tehachapi Mountains and southern Sierra Nevada. We fear there is a high probability of condor mortalities by turbine collisions during the permit duration.

At least two rare rodents recommended for coverage, the yellow-eared pocket mouse and Tehachapi pocket mouse, have extremely limited ranges that correspond closely with areas of high wind potential on the slopes of the southern Sierra Nevada, Tehachapi, and Transverse Ranges. The rarity of these species suggests that intensive surveys should be performed to identify and avoid occupied or potential habitat areas for direct impacts of wind-farm developments (including roads, etc.). Turbines and other facilities should be designed to eliminate perching by raptors, to avoid elevated predation pressure on these nocturnal rodents, especially by owls.

Bat fatalities have been found at every wind facility in North America that has been specifically monitored for bats. Large fatality events were first documented on forested ridges in the eastern U.S, but more recent studies have documented high fatality rates in plains and agricultural habitats of the Midwest and western Canada (Arnett et al. 2009, Baerwald and Barclay 2009a). Most studies find that migratory species during the migration season account for the greatest

[8] At least one advisor has observed migratory water birds becoming trapped between stacked pipes at construction sites in desert areas, because the birds apparently mistook the pipes as water bodies and attempted to land on them.

number of mortalities (Arnett et al. 2008). There is little information on bat migration patterns in the desert southwest, but a recent study found that the majority of bat fatalities at a wind energy facility near Palm Springs occurred during presumed periods of migration (Chatfield et al. 2009). This provides hope that fatalities may be somewhat predictable in time and therefore avoidable by managing turbine operations adaptively.

2.10.5 Geothermal Projects

The advisors are not experts in geothermal projects or their impacts on biological resources, and we did not specifically discuss recommendations for such projects. In general, we note that current and proposed geothermal developments occur near the Salton Sea and its various open-water, shoreline, riparian, marsh, and agricultural habitats that support abundant bird life. Associated transmission lines, night-lighting, construction and maintenance activities, and water usage likely have adverse impacts on a number of covered species. It is our observation that impacts of current geothermal development at the Salton Sea have come mainly from their siting (near or even on important wildlife habitat), and some of us have observed mortalities of large birds hitting transmission lines during flight near the Salton Sea. We also note that water consumption of geothermal plants may be a concern (although we understand this varies greatly depending on specific technologies, such as whether and how water is reinjected).

3 Principles for Addressing Information Gaps and Uncertainties

Gaps in available information on biological resources are always among the biggest sources of uncertainty for regional conservation plans. Here we address some approaches for filling these data gaps and dealing with scientific uncertainty.

3.1 Environmental Base Maps

Accurate and reliable maps of ecological, climatic, and geological features and species distributions are essential to good conservation planning and their lack represents a critical information gap.

3.1.1 Vegetation Maps

For DRECP, accurate, up-to-date, and fine-resolution land cover or vegetation maps are a key data gap. Vegetation mapping is not comprehensive across the plan area, and mapping efforts vary in detail, approach, and accuracy in different regions (Appendix F). Currently, there is no detailed vegetation map, nor a special features map, for the western Mojave Desert. The advisors recommend that both an alliance-level vegetation map and a special botanical or vegetation features map be assembled for this area, much like the one that was developed for the central Mojave (Thomas et al. 2004). While the central Mojave special features map may need updating and refinement, it does represent a well-executed initial effort for defining natural communities. New mapping efforts to assemble an alliance-level map should be based on high quality digital imagery and should be delineated and labeled using standard CDFG vegetation protocols (http://www.dfg.ca.gov/biogeodata/vegcamp/pdfs/Final_SB_85_Report.pdf).

Unfortunately, creating a comprehensive, alliance-level vegetation and special features map for the entire western Mojave region would take approximately 18 months once sufficient funding is provided to secure contract mapping, which would augment mapping that could be accomplished through CDFG's Vegcamp efforts during the same time period (T. Keeler-Wolf, personal communications). Given this is not possible under the DRECP schedule or available funding, vegetation alliance and special features mapping should be prioritized within currently unmapped regions most likely to be affected by renewable energy developments, such as renewable energy study areas in the Western Mojave west of Barstow and around Owens Lake.

An option for providing a useable vegetation map on a rapid schedule would be to create an "interim" or mid-level vegetation map that lacks some of the detail, field survey data, and accuracy assessment needed for a final map, but that would nevertheless be an improvement over the current situation. The interim map could be completed in less than 18 months by compiling new and existing vegetation maps with minor reformatting to allow for standardized representation. It could be produced by photo-interpreters familiar with California desert vegetation and supplemented with field reconnaissance. Individually attributed polygons would contain information on alliance or alliance groups (compliant with the National Vegetation Classification System [NVCS] mid-level hierarchy based on ecologically aggregated groups of alliances [FGDC 2008 in Sawyer et al. 2009]), basic structure (cover classes, height classes), and stand quality (attributes for degree of "roadedness," invasive exotic cover, and other easily interpreted attributes). An interim map, as described, would lack the detail needed for a final map, as well as a rigorous accuracy assessment and a complete synoptic revision. In addition, it would not be reliable in all attributes or spatial representation. Nonetheless, it would better determine the distribution of vegetation, including unique or rare vegetation types, than existing, broad-scale, maps. It would also represent an improvement over existing low-resolution vegetation maps for purposes of habitat or species distribution models. The interim map would be merged with re-scaled, existing data-driven vegetation maps for the central and eastern Mojave and several of the large state and national parks to create a single vegetation data layer that would provide an improved, baseline map for regional planning.

However, it is important to recognize that such an interim, mid-scale map is a compromise and should not be considered a final product: We believe that a comprehensive, fine-scale, alliance-level vegetation map supported by rigorous field data collection over multiple years and a formal accuracy assessment per CDFG protocols, should be completed as soon as possible, whether it can be finished prior to the draft DRECP, or after the draft plan for use during plan implementation

See Appendix F for a more comprehensive review and recommendations concerning vegetation mapping in the planning area.

3.1.2 Special or Unique Plant Assemblage Mapping

The advisors recommend that a special features map similar to that created for the Central Mojave Vegetation Database (Thomas et al, 2004) be made for the rest of the planning area. It would serve as a template for the development of a database describing rare or localized vegetation types, habitats or plant species. The Significant Natural Area approach for the western Mojave could be used for this map as several species or vegetation occurrences overlap and can be used to identify spatially explicit units for conservation which would otherwise not be shown on the alliance level vegetation map.

The following excerpts from a metadata report for special features coverage for the Central Mojave Vegetation Database specify methodology that could be used as a model for creating a comprehensive special features map for the entire planning area. Refer to the entire metadata report (see Appendix F) for additional detail on the types of entities covered in the special features layer for the Central Mojave Vegetation Database.

The Central Mojave Special Features coverage is composed of point locations representing a rare/special vegetation alliance, unique stand, or a feature with co-occurring or potential vegetation alliances. Each point location was obtained from existing digital map databases, hard copy source maps, literature descriptions, or field work conducted for this project or other Mojave Desert field projects.

Other special features such as wetlands and rare plant occurrences were added to the point coverage. Locations of springs were added to the Central Mojave Special Features map database from USGS Digital Line Graph (DLG) map databases (1:24,000 and 1:100,000) which resulted in 640 spring locations. Riparian and wetland features for portions of Death Valley were extracted from the National Wetlands Inventory (NWI) map database. Some of those features are known to be devoid of vascular vegetation (e.g. salt flats); however, other features are known to be vegetated. Point locations for crucifixion thorn (*Castela emoryi*) were obtained from map databases developed by the Bureau of Land Management in association with the Northern and Eastern Colorado Desert planning effort.

3.1.3 Other Important Maps

A variety of existing maps and GIS data layers should be consulted during planning and incorporated into a central GIS database for use in spatially explicit models or other purposes, including:

- Surficial geologic maps available from the California Geological Survey (http://www.consrv.ca.gov/cgs/information/geologic_mapping/Pages/index.aspx) and the U.S. Geological Survey (http://ngmdb.usgs.gov/).
- Soil and substrate geospatial data, which can be obtained from a combination of surficial geologic maps and data developed by the National Resource Conservation Service, including the STATSGO and SSURGO databases (http://soils.usda.gov/survey/geography/statsgo/; http://soils.usda.gov/survey/geography/ssurgo/).
- Disturbance maps (recent or historic ORV, military training, homesteads, agriculture, livestock grazing, brownfields, etc., that would affect soil surface and vegetation). If no existing map combines these sorts of disturbances, such a map should be created to identify preferential areas for siting renewable energy projects. The U.S. Bureau of Land Management, California Desert District, Moreno Valley, has such maps.
- Wildlife linkage, movement corridor, and habitat connectivity maps, including at least the following:
  - South Coast Missing Linkage Project Linkage Designs that are at least partly within the DRECP Area (available at http://scwildlands.org/index.aspx).
  - Least-cost corridor models and habitat suitability models for diverse focal species, and draft Linkage Designs to accommodate a broader range of species are currently being prepared by SCWildlands for the California Desert Connectivity Project (Penrod et al., in preparation).
  - Natural Landscape Blocks and Essential Connectivity Areas mapped for the California Essential Habitat Connectivity Project (Spencer et al. 2010). Links to download the report, maps, and GIS data are at www.dfg.ca.gov/habcon/connectivity/.
  - Dispersal and least-cost path models for desert bighorn sheep identified by Epps et al. (2007).
- Fire maps (contact Matt Brooks at USGS for up-to-date maps).
- Nitrogen deposition maps (from Drs. Ellen Bauder and Edith Allen, UC Riverside).
- Fault lines (associated with concentrations of springs, seeps, and hanging gardens). These can be determined from geologic maps.
- Audubon Important Bird Areas.

- Paleo site data.
- BLM maps of permit applications to identify conflicts between proposed projects and potential reserve areas.
- Maps of critical habitat and/or sensitive habitats for rare, threatened, and endangered species from existing documents.
- Maps of existing or proposed Wilderness; designated Research Natural Areas, Natural Areas, and Areas of Critical Environmental Concern.
- Road density map, with indicating differences between paved roads, dirt or gravel roads, graded or ungraded roads, etc.
- Existing utility lines, corridors, fiber optic cables, aqueducts and other linear features, including information on width of rights-of-way and disturbed areas.
- Map of water sources, springs, seeps, rivers, streams; map of primary, secondary, tertiary and other washes.
- Google Earth is a good aerial imagery tool, especially using the "history" option, which can reveal areas subject to historic disturbance.

Note GIS data layers vary in their reliability, accuracy, and recency. All data should be carefully reviewed and assessed for accuracy in the field prior to use in models or for planning.

3.2 General Information Sources

The following information sources about desert ecology and species should be consulted during plan preparation:

- Berry, K.H., and R. Murphy. 2006. Deserts of the World Part I: the Changing Mojave Desert. Journal of Arid Environments 67, Supplement, Special Issue.
- Pavlik, B. 2008. The California Deserts. University of California Press.
- Rundel, P.W., and Gibson, A.C. 1996. Ecological Communities and Processes in a Mojave Desert Ecosystem, Rock Valley, Nevada. Cambridge University Press, 369 p.
- Shuford, W.D., and T. Gardali (eds.). 2008. California Bird Species of Special Concern: a ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of western birds, no. 1. Western Field Ornithologists, Camarillo, CA. and California Department of Fish and Game, Sacramento, CA.
- Webb et al. 2009c. The Mojave Desert: Ecosystem Processes and Sustainability. University of Nevada Press, Reno, Nevada.
- Whitford, W. 2002. Ecology of Desert Systems. Academic Press, London.
- Wilshire, H.G., J.E. Nielson, and R.W. Hazlett. 2008. The American West at Risk. Science, Myths, and Politics of Land Abuse and Recovery. Oxford University Press, New York.

3.3 Species Locality Data

In addition to CNDDB and other databases maintained by CDFG in the BIOS program (http://bios.dfg.ca.gov/), there are a variety of sources of species locality data that should be incorporated into BIOS or a central DRECP database and used in species distribution modeling, including at least the following:

- California Mammal Species of Special Concern database (MSSC; Spencer et al. in prep; database expected to be available by late 2010; range maps in 2011).
- PRBO Conservation Science and the California Avian Data Center (www.prbo.org/cadc) which is a node of the Avian Knowledge Network.
- Cornell Laboratory of Ornithology's eBird database (http://ebird.org/content/ebird)
- Local BLM offices conducting biotic inventories.
- Museum records. Digital databases are now available for many museum collections, including ORNIS for avian museum databases (http://ornisnet.org/) and MaNIS (http://manisnet.org/) for mammals[9], HerpNET (http://www.herpnet.org/herpnet/index.html) for amphibians and reptiles, and the Consortium of California Herbaria (http://ucjeps.berkeley.edu/consortium/), and the San Diego Natural History Museum's Plant Atlas (http://www.sdnhm.org/plantatlas/index.html) for plants.
- Site-specific information from EIRs and EISs (compiled into a central database).

3.4 Species Habitat Suitability and Distribution Models

Information on species' distribution and abundance are critical inputs to conservation planning. Range maps are not always available for individual species. Survey data may be used to infer distributional limits or abundance if they are comprehensive and collected broadly across the regions. However, because comprehensive survey coverage is not feasible for most species, we recommend judicious use of habitat suitability models or species distribution models (SDMs). SDMs allow point locality data to be extrapolated to determine probability of occurrence maps which may be used to infer species presence or habitat suitability over broad areas, including areas not previously surveyed. Where data are sufficient, empirical or statistical models based on species locality data (or presence-absence data) are preferred. Where data are not sufficient for empirical models, careful use of "expert-opinion" models may be warranted. Moreover, in cases where available survey data are strongly spatially biased, or for species that may have been extirpated from areas of suitable habitat, habitat distribution models based on expert opinion may be more appropriate than models built using species locality data (Early et al. 2008).

3.4.1 Empirical or Statistical Models

Empirical (statistical) modeling approaches are better than simple GIS overlay or "query" models that are often used in conservation plans as proxies for mapping habitat values or

[9] Note, however, that MaNIS data have been incorporated into the MSSC database.

predicting species distributions. Although the overlay method is useful as an initial step for exploring which factors, *of those available in the GIS*, seem to be associated with species occurrences (e.g., they are more useful as *exploratory* rather than *forecasting* models; O'Connor 2002), the resulting maps inevitably contain significant errors if used to represent or predict species distributions, at least in part because they cannot account for interactions among variables in affecting habitat suitability. Statistical SDMs have the added benefit of specifically quantifying uncertainties in model predictions.

Species distribution (or occupancy) modeling is a very active and constantly evolving research field with numerous recent advances (Elith et al. 2006, Elith and Leathwick 2009; http://biodiversityinformatics.amnh.org/index.php?section=sdm_guide). SDMs use environmental variables characterizing places where a species does (or does not) occur based on survey data to develop sophisticated correlative models. SDMs may also be extrapolated to project future occurrences in places where the correlated environmental features are projected to be present in the future (Wiens et al. 2009). Care should be taken to select a modeling approach and SDM algorithm that performs well based on recent peer-reviewed literature and which is appropriate for the organism being modeled. It may be prudent to model the data with more than one SDM algorithm and examine overlap among model outputs ("consensus modeling"), as well as the amount of uncertainty among model outputs (see Wiens 2009 for an example of uncertainty analysis).

We emphasize the importance of expertise and rigor in applying these highly technical models. In our collective experience, this expertise is generally lacking at environmental consulting firms that prepare HCPs, NCCPs, and NEPA and CEQA documents. However, there is a growing pool of appropriate expertise at academic research institutions, science-based NGOs, and science-based government agencies, such as USGS. *We urge DRECP to tap appropriate expertise for the application of any scientific models, because learning-while-doing is inefficient and error-ridden*.

To construct a SDM, the following components and steps are needed: acquisition of biotic inventory data, selection of relevant environmental variables, selection of one or more SDM algorithms, selection of spatial scale, evaluation of model results, and interpretation of the resulting output. All of these steps should be well documented and defended when presenting model output results.

- **Biotic inventory data**: Ideally biotic inventory have been collected over the range of geographic and environmental space that one wants to create a model for. Systematic or random sampling designs are ideal, but almost never possible and not essential. Occupancy modeling approaches (MacKenzie et al. 2006) can control for species detectability and can be used to augment or expand simple presence localities.
- **Algorithm selection**: Ideally, species distribution models should be built using empirical, statistical methods, such as generalized additive models (GAM) or hierarchical regression models (see Scott et al. 2002, Guisan and Thuiller 2005, Beissinger et al. 2006, Elith et al.

2006, and Elith and Leathwick 2009 for recent reviews)[10]. Some algorithms are appropriate for presence-only data (e.g., from museum records or CNDDB), while other algorithms incorporate presence and absence inventory. Because new algorithms are constantly being developed, care should be taken to select an algorithm that has been well documented in the recent peer reviewed literature.

- **Selection of environmental variables**: Carefully think through *all* environmental factors most likely to affect each species' distribution, and how these factors may interact (e.g., vegetation, geologic substrate, terrain, hydrology, climate, insolation, other species). Species experts and the literature should be consulted to determine the relevant environmental factors. Avoid combining redundant (highly correlated) factors within a model, and select those variables most likely to explain variations in habitat quality. In doing this, recognize that there are many useful environmental variables that can be derived from existing GIS layers, such as indices of habitat patch size, fragmentation, distance from water, primary productivity, insolation, or road densities.
- **Selection of spatial scale**: The spatial scale should be relevant for the taxa of interest, as well as incorporating the scale of the environmental variables (e.g., some environmental variables are only available at 800m or 1km sized pixels). The grain size selection may affect model results (Guisan et al. 2007). Most SDMs involve averaging variables over a "moving window" of a size relevant to the species in question, based, for example, on the species' average home range size or the scale at which individuals select habitat areas.
- **Evaluation of model results**: The resulting SDM output should be statistically evaluated. There are a variety of approaches for assessing predictive performance and selecting test statistics. If a model performs poorly it should be documented and potentially re-run with alternate environmental data, additional biotic inventory data, or some other considerations based on input from experts on the taxa. Usually, a variety of alternative or "candidate" models are created using different combinations of variables, where each combination of variables represents a reasonable hypothesis about what factors interact to influence habitat suitability. These candidate models are then statistically compared or "competed" (using information-theoretic metrics) to select a single "best" model or a combination of models that may be averaged together (Burnham and Anderson 2002).
- **Interpretation of output**: Most statistical models produce continuous gradients of a species' probability of occurrence, or at least multiple categories of habitat value, which can be more revealing for conservation planning than discrete suitable/unsuitable habitat maps. Ideally an expert on the taxa can review the final model output. It is important to realize that probability of occurrence is just that: species sometimes are found in places with a low probability of occurrence, and may sometimes be absent from those with a high probability—because random events and stochastic processes are common in nature. Maps that represent habitat in a simple suitable-nonsuitable format, or species occurrence as a simple presence or absence format, are generally misleading.

[10] A number of sophisticated software packages for analyzing species distribution data are now freely available, such as MaxEnt (www.cs.princeton. edu/ ~schapire/maxent).

3.4.2 Expert-opinion Models

Unfortunately, empirical SDM models often require more species location points than are available (especially for rare and endangered species), and they may not be appropriate if there is a great deal of spatial bias in the underlying data or for species that are absent from areas of suitable habitat due to other factors like predation, collecting, or disease, or species with strong metapopulation dynamics that cause populations to appear and disappear in suitable habitat over time (Early et al. 2008). Under such conditions, we endorse cautious use of "expert opinion" habitat distribution models, so long as they adhere to some guidelines to be as reliable as possible.

Base the models as much as possible on peer-reviewed literature, and obtain expert review of models. Use model logic to capture how environmental variables interact to affect habitat value. Most GIS query models use simple Boolean "and" logic (i.e., a species may occur if a site has the right soil AND vegetation AND elevation, etc.). However, other logical interactions (e.g., using Boolean "or" logic) may also apply (i.e., a species may occur in vegetation type A at low elevation, OR type B at higher elevation, etc.). A full review of these concepts is beyond the scope of this report, but we recommend reviewing Scott et al. (2002), Guisan and Thuiller (2005), Beissinger et al. (2006) or other recent reviews of habitat modeling for ideas. Regardless of what model approach and variables are used, uncertainties in model predictions should be clearly articulated and considered in any decisions based on them.

SCWildlands has prepared expert-opinion habitat models for 48 focal species in California deserts for the California Desert Connectivity Project (Penrod et al. in preparation). These models use variable scoring and weighting factors developed by species experts using a variety of available GIS environmental data layers. Data classes relevant to habitat suitability for each species were scored from 1-10, and the scores were combined using weighted arithmetic or geometric means to rank habitat suitability from low to high, using such variables as vegetation type, elevation, terrain ruggedness, distance from water, and road density. The advisors did not have time to comprehensively review the draft SCWildlands models for this report. We recommend that they be subject to peer review to determine their potential utility to DRECP.

3.5 Decision Support Models

Decision support models are increasingly recognized as tools to guide decision making for natural resources and systems in complex landscapes (Llewellyn et al. 1996, Leung 1997, Seavy and Howell 2010). Informed decision making for the addition of renewable energy facilities and their infrastructure to the desert southwest may be greatly facilitated by this process. The benefits of spatially explicit decision support systems include (1) the ability to balance interacting land uses while considering resource values and existing land use agreements, (2) merging data from multiple sources such that potential conflicts, interactions and synergisms can be readily identified and openly discussed among interested parties, (3) analyze landscapes (e.g. this 23,000,000 ac study area) in consideration of realistically complex management situations, and (4) the process is highly documented, repeatable, and can be readily modified to explore alternatives by all interested parties (Heaton et al. 2008).

Within this framework, one important consideration is the nature of the modeling input. Decision support models can be formulated using deterministic and probabilistic data, as well as expert opinion (see Section 3.4). The distinction among these data sources should be explicitly stated within the context of model documentation. Furthermore, any of these data may be available from peer-reviewed documents, gray literature, or expert opinion, and the source of information should also be explicitly stated. The distinction among data sources can have important ramifications for the end product and the integrity of the process. Models based on empirical data and vetted by peer review provide a level of confidence, but availability of such models is limited. In contrast, expert opinion models or models not vetted by the peer-review process are more readily available, but confidence in their outputs is generally lower. Hybrid models based on inputs from all potential data sources may provide the broadest potential for exploring the complex issues related to energy, resources and societal needs and creating realistic scenarios. Therefore hybrid models are a potential construct, but the nature of all inputs should be explained in detail so reviewers understand the limitations and uncertainties.

Acquiring data and ensuring its reliability can be a very challenging aspect of this type of work. To the greatest extent possible, reliable and thoroughly reviewed data sources that are already assembled should be relied on, as data assembly and review is time consuming and expensive. Compatible data sets that are previously assembled and peer reviewed should be acquired and used to the greatest extent possible.

3.5.1 Desert Tortoise Spatial Decision Support Model

An example decision support model with direct applicability to DRECP exists for the desert tortoise. The following information is provided courtesy of Cat Darst of the USFWS Desert Tortoise Recovery Office:

> The Desert Tortoise Recovery Office spatial decision support system identifies and prioritizes actions that are most likely to ameliorate threats to tortoise populations at any geographic extent (>1 square kilometer) within the tortoise's range. To do this, the decision support system utilizes GIS data of the spatial extent of threats (*i.e.*, where threats occur geographically) to calculate how changes in threats contribute to changes in tortoise population numbers.
>
> The decision support system models the relationships between threats, population stresses, and demographic change factors. The relationships within the model are weighted using institutional understanding of the strengths of: (1) inter-threat links, (2) threat to population stress links, and (3) population stress to demographic change links. The GIS data of the spatial extent of threats are then geoprocessed with these weights to calculate how changes in threats contribute to changes in tortoise population numbers and how recovery action implementation is predicted to ameliorate those threats.
>
> Future versions of the decision support system may permit managers to conduct gap analysis on their current/planned recovery actions (*i.e.*, compare ideal to current or planned management actions to identify gaps in management prescriptions for a given area) or to evaluate actions in terms of their near- vs. long-term contribution to recovery. The decision support system may also be used to develop prioritizations that account for economic,

political, and operational constraints that managers face when implementing recovery. All data and underlying models will be updated and evaluated on a regular basis.

The DRECP independent science advisors recommend considering use of the Desert Tortoise Decision Support Model for assessing and comparing plan alternatives, and considering whether similar systems can and should be developed for other resources of interest. If not already done, the model should be subject to peer review before application. Most important, the current environmental data layers used in the model are known to have errors (C. Darst, personal communications) and require updating and corrections before they can be depended on. Nevertheless, given that the input variables are adequate, such decision-support tools could be used to compare the relative likely effects of alternative development-conservation-mitigation-management scenarios on the species, and thereby select combinations of actions most likely to contribute to the conservation and recovery of the species.

3.5.2 Spatially Explicit Population Models

Spatially explicit population models (SEPM) are more quantitative extensions of the sorts of decision- support models discussed above, and provide a powerful means of comparing alternative conservation strategies for rare or endangered species (Carroll et al. 2003, Carroll 2007, Spencer et al. 2008, Carroll et al. In Press, Spencer et al. In Press). SEPMs track the fates of many simulated individuals through time as they move across a grid of cells in a geographic information system (GIS) environment—and grow, reproduce, disperse, and die. The software package HEXSIM (http://www.epa.gov/wed/pages/models/hexsim/index.htm, which updates an earlier version called PATCH; Schumaker 1998), links the survival and fecundity of individuals or groups of animals to data on mortality risk and habitat productivity at the scale of an individual territory (or a pack territory for social groups). Population vital rates can be weighted based on habitat suitability—for example, with higher mortality rates or lower reproductive weights in suboptimal habitats. The behavior of large numbers of individuals, over a large number of replicate simulations (to account for effects of stochasticity) is then used to determine the range of likely fates for the population under alternative scenarios and to assess uncertainties about the likely outcomes. Hence, SEPMS can be used to make relative comparisons of how a population or metapopulation may fare under alternative future scenarios—such as alternative reserve designs, development scenarios, types of management intervention, or assumptions about future climatic or other conditions (Spencer et al. 2008, Carroll et al. In Press, Spencer et al. In Press).

SEPMs are data hungry, however, and are best used on species for which there is reasonably good information on species' demographic rates and processes (e.g., reproductive rates, mortality rates, dispersal characteristics) and how these may vary with habitat condition. We recommend exploring the use of SEPMs to compare among plan alternatives for a few key covered species for which there may be sufficient data to parameterize models, especially desert tortoise and bighorn sheep. Other species for which the approach may be useful (given adequate demographic data) include Mohave ground squirrel, flat-tailed horned lizard, and leopard lizard.

3.6 Anticipating Climate Change

The world of climate-change modeling, and of predicting the responses of species and ecological communities to climate change, is developing rapidly, but large uncertainties remain (e.g., Oreskes 2004, Hayhoe et al. 2004, Wiens et al. 2009, Stralberg et al. 2009, Beier and Brost 2010). What is certain is that desert climates will change to the detriment of many species, and that some species ranges will shift, creating new and novel ecological communities, and thus new interactions with uncertain effects. And, contrary to popular perception, new studies are suggesting that the pace with which species may need to adapt or shift their ranges in response to climate change may be more dramatic in broad, relatively flat terrain (like deserts, plains, and grasslands) than in more dramatic, mountainous terrain (Loarie et al. 2009, Stralberg et al. 2009).

The following concerns about predicting climate-change effects on species distributions are based on comments submitted by a peer reviewer of this report (Dr. James Patton, Professor Emeritus, UC Berkeley): Most climate-effects distribution models have been based on climate variables alone (typically the Bioclim variables), whereas soil types, geological formations, plant communities and other variables are also important to many species. Plant communities will reflect local climates to some degree, but climate alone cannot predict future plant combinations that will be important to animal species. The data points used for distribution modeling are also important: We know that there have been range shifts over the past century, but we don't know if those shifts have been monotonic with time or if an abrupt distributional shift occurred in a particular focal time-period. Studies like the Grinnell Resurvey Project (http://mvz.berkeley.edu/Grinnell/research/index.html) reveal that not all species have shifted their ranges (about 50%), and for those that have, the shift is not always in the same direction. Hence, distribution modeling for two known points in time (early 20th century and today) does not predict current distribution no matter how good the "fit" is for either of these time periods. As a consequence, projecting to the future from today alone for any particular species is problematic at best.

We recommend that participants continue to track the evolving scientific literature on climate change effects in the planning area, *while planning a reserve network that is as comprehensive and robust as possible to this uncertain future. This means conserving large areas that encompass broad environmental gradients (e.g., a wide range of latitudinal, longitudinal, elevational, climatic, and geological conditions) within an interconnected reserve network (to allow the greatest potential for range shifts), and that it maximize conservation of ground and surface waters, riparian areas, and washes to maximize resiliency in the face of climate change*.

A promising analytical approach to consider using in designing a reserve system that is robust to climate change is the land-facets approach advocated by Beier and Brost (2010). This approach recognizes that species distributions are largely functions of climate—which changes—in concert with physical attributes of the landscape (especially soils, elevation, topographic position, and exposure to sunlight)—which are much more stable over time. Conserving interconnected areas that represent the full spectrum of these physical, landform attributes, may allow species to shift their distributions with climate change while remaining within their favored physical niche.

The plan should also anticipate the need to monitor and respond to changes via the adaptive management and monitoring program, which will entail establishing comprehensive baseline monitoring stations as soon as possible (Section 6.4).

Where sufficient SDMs exist for species (Section 3.4) based on current climate data, future projections should be made to determine how species distributions may shift under climate change. These sophisticated models should be based on the latest peer reviewed methods and climate models (Wiens et al. 2009) and should include measures of uncertainty where possible.

4 Principles for Conservation and Reserve Design

This section provides a review of the [11]REAT "starting points" maps and recommends approaches for designing an ecological reserve network in the planning area to sustain biological diversity, natural ecological communities, and ecosystem functions. It also provides some guidance for siting, configuring, and mitigating developments to minimize adverse effects to desert ecosystems. Section 5 provides further details for selected covered species and communities.

4.1 Review of REAT "Starting Point" Maps

At our April 2010 science advisors' workshop, REAT representatives presented some preliminary maps intended to help guide where conservation actions and renewable energy developments should be sited. The REAT maps can be improved by more careful use of existing data, increased transparency in methods, and more rigorous application of reserve-design principles and models, as detailed below. Among the potential problems with application of the REAT maps were the following:

Inappropriate use of species locality data points to prioritize areas of conservation concern. We recommend that DRECP a*void using species observation locality data (e.g., from the California Natural Diversity Data Base, CNDDB) as a primary foundation for siting development or conservation actions using GIS overlay models*. Because CNDDB (and other locality databases) are compiled largely from incidental observations, rather than systematic surveys or random sampling programs, they are inherently spatially biased—and *absence of points from a locale cannot be interpreted as absence of the species*. The advisors were not provided details concerning the ranking methods and criteria used to create the REAT "species sensitivity ranking" maps, but we understand that CNDDB data (along with other unspecified data sources) were weighted based on species conservation sensitivities and then combined using GIS overlay techniques. Because we cannot account for spatial survey biases in this approach, the advisors cannot concur with the interpretation that "the darker the color the higher the sensitivity," or conversely, we have no confidence that areas lighter in color are necessarily of lower biological value.

CNDDB data represent an incomplete and inaccurate means for assessing species of conservation concern in the area (see Section 2.5 for errors of omission and commission from the draft covered species list, apparently resulting from using CNDDB to generate the list). CNDDB prioritizes species that are considered of conservation concern, but such lists change over time and CNDDB does not provide comprehensive coverage. Numerous rare and sensitive taxa are not included in CNDDB or have very few observations in the database—for example, in the case where a species was only recently added to a conservation concern list. In addition, CNDDB data are processed and uploaded at irregular intervals, with emphasis placed on different geographic regions of the state in different years. Perhaps most important, many of the sensitive

[11] REAT is the Renewable Energy Action Team, with representatives from US Fish and Wildlife Service, California Department of Fish and Game, California Energy Comission, Bureau of Land Management, and the California Natural Resources Agency.

taxa within the DRECP region are *subspecies* rather than full species, and data that do not consistently differentiate subspecies should not be used if one cannot determine whether a species record represents a relatively common or rare subspecies. Finally, great care should be taken in relying on any locality data that are not supported by vouchered specimens residing in a repository (herbarium or museum collection) upon which the identification can be verified. Taxonomy changes and uncertainties in identifications made by different observers vary too substantially to base important decisions on non-vouchered records.

Because of these concerns, CNDDB data, or any similar locality data, are best used as inputs to objective and appropriate modeling algorithms that can be used to project likely species distributions over unsurveyed areas (see Section 3.4), or to help verify or supplement other objective depictions of species distributions, rather than as primary predictors of species distribution and especially of species absence. *In the absence of appropriate, spatially explicit models or maps of species distributions, use "no regrets" approaches that site developments in areas already irreversibly converted by previous disturbance, and site conservation actions in areas already known to be important for sustaining covered species and communities, as detailed below.*

Inappropriate use of species range maps. Use of species range maps from the California Wildlife Habitat Relationships (CWHR) program suffers from similar problems as use of CNDDB data. Although the current protocols for CWHR range map revisions (Hooper et al. 2009, unpublished) are technically sound, most CWHR range maps have not been updated based on these protocols, and many are coarse in resolution and out of date. In many cases they have not been updated to reflect recent taxonomic changes. Moreover, to our knowledge CWHR range maps exist only for full species, not for subspecies. Overlaying species range maps to identify "hotspots" of sensitive species occurrences can therefore be highly misleading. For example, although the round-tailed ground squirrel, little pocket mouse, and Merriam's kangaroo rat are all very widespread species (see Section 2.5), their rare, endemic, and listed subspecies are very narrowly distributed; thus, use of the species range maps provides a distorted picture of areas most important for conserving sensitive taxa. *If GIS overlay methods are to be used to help identify areas of high or low conservation concern, great care should be taken to use range maps that accurately portray the ranges of the taxa of concern.*

Creating a single composite map of multiple environmental data layers without adequate analytical transparency. The advisors reviewed REAT maps showing "conservation opportunity areas" described as supporting "key populations or connections between key populations." The potential value or application of these maps is not clear without differentiating the various species, populations, or connections comprising it, and without explaining the methods used to produce the composite. Moreover, it is impossible to compare differing biological values or constraints on different parts of the map, which is essential to insightful prioritizing or phasing of conservation actions. Future maps should clearly differentiate, for example, existing reserve areas, unconserved areas, modeled habitat connectivity areas, species' ranges, and other important inputs to inform decision-making. If a single summary or composite map is desired for simplicity (e.g., for public outreach), the individual data layers (and how they were derived and treated in the composite) should be made available, and the compositing criteria and methods clearly articulated. *It is critical that all analyses and decision-making processes be as transparent and understandable as possible.*

4.2 Reserve Design Process

Reserves (otherwise known as protected areas, conservation areas, preserves, etc.) have been a cornerstone of conservation for centuries (Grove 1992). There has been a recent shift in perspective toward viewing landscapes as wholes in conservation planning, with increased attention to the contributions to conservation from the landscape matrix (i.e., mixed-use areas), rather than solely from reserves. Nevertheless, areas protected from intensive human use remain fundamental to conservation planning, because many species, communities, and processes are sensitive to human activity (Noss et al. 1999).

Principles for conservation planning and reserve design emerged as empirical generalizations based on case studies such as conservation of the northern spotted owl (Wilcove and Murphy 1991) and the southern California coastal sage scrub (Noss et al. 1997). These principles have been bolstered and refined over time with experience in diverse settings and planning contexts worldwide. The advent of systematic conservation planning and the increased use of sophisticated site-selection algorithms and spatially explicit habitat and population models (Margules and Pressey 2000, Carroll et al. 2003, Moilanen et al. 2009, Spencer et al. In Press) has made conservation planning more rigorous and quantitative, but sometimes at the cost of making conservation plans less comprehendible to land-use planners, decision-makers, and the general public, and often through a protracted process that defeats the original proactive intent.

For the DRECP *we recommend a phased conservation planning process, which takes full advantage of the considerable conservation and recovery plans already available for the region.* This phased approach will allow planners to make immediate “no regrets” decisions on important areas to conserve, areas where renewable energy projects can be sited, and methods for mitigating adverse effects of development—while at the same time performing additional conservation planning analyses to fill gaps in understanding and guide more difficult decisions. These analyses should be performed using a fully transparent process that incorporates empirical design principles and expert guidance. In other words, *the plan should be developed in an incremental, adaptive-management framework (as detailed in Section 6), evolving over time, both before and during implementation, as new information becomes available to fill our knowledge gaps.* Thus, some development and conservation can proceed as the planning process develops, guided at least in part by sophisticated modeling to help verify and refine what is already known. We offer the following principles as guidance for a comprehensive and systematic approach to planning a reserve network for DRECP.

4.2.1 Make Use of Existing Planning Documents

Conservation planning rarely happens in a vacuum, and DRECP has the benefit of numerous existing, science-based plans and analyses to use as a foundation. *We recommend that DRECP implement and improve on conservation actions identified by existing conservation and recovery plans in the planning area, beginning as soon as possible.* Considerable scientific input has already been applied in delineating important conservation areas and designing specific conservation and mitigation actions to preserve and recover sensitive desert species and communities in such documents as the Western Mojave Plan, the Northern and Eastern Colorado Desert Coordinated Management Plan, the Desert Tortoise Recovery Plan, the CalPIF Desert

Bird Conservation Plan, and ecoregional assessments prepared by The Nature Conservancy and other NGOs (see Appendix G for additional documents pertinent to conservation planning in California deserts). However, few of these conservation actions have actually been implemented, in large part due to lack of sufficient funding and staffing at the responsible agencies (Bunn et al. 2007). *Mitigation for renewable energy developments should be used to help rectify this situation by providing funding to implement appropriate conservation and recovery actions identified in existing plans, and to improve these plans over time via the DRECP Adaptive Management and Monitoring Program.*

In addition to plans prepared by government agencies, The Nature Conservancy, SCWildlands, Conservation Biology Institute, PRBO Conservation Science, and other research and planning NGOs have been developing maps and plans for conserving desert resources in recent years, using many of the types of sophisticated GIS models and decision-support tools recommended in this document. Although the science advisors have not comprehensively reviewed this body of work or specifically compared and contrasted their approaches with our recommendations, we believe such assessments are valuable references to build on for identifying DRECP conservation areas and actions. Rather than re-invent wheels, *DRECP should carefully review all such existing conservation assessments and plans and prioritize and phase implementation of the most useful and scientifically justified actions they recommend*. This review should consider our recommendations as general guidance, and should involve adequate scientific oversight and peer review of important documents or decisions.

4.2.2 Subdivide the Planning Area and Scale Each Task Appropriately

As detailed in Section 2.2, *we recommend dividing the planning area into several regions or planning units that are both ecologically relevant and potentially useful for dealing with the likely clustering of renewable energy developments* in different regions. Importantly, however, while planning subdivisions may be convenient and scientifically defensible across numerous planning tasks and analyses, they should not be universally applied to all species, communities, or analyses of interest (i.e., *don't assume "one-size-fits-all"*). Some analyses may need to be done at the scale of the entire DRECP area, others at more local or regional scales. If planning subdivisions are developed, consider whether they are appropriate for each analytical task, or whether combining, merging, or further subdividing the units is justified for any particular map, model, or analysis.

For some species, subregions might be best defined based on the species' demographic and genetic population structure across the planning region. For example, the desert tortoise recovery units, which are based on core tortoise population areas and genetic differences among them, may be most appropriate to use for that species. However, for most DRECP communities and species, subdivisions based on Ecological Sections and Subsections (Miles et al. 1998; http://www.fs.fed.us/r5/projects/ecoregions/toc.htm) or the subdivisions delineated by Webb et al. (2009a) for the Mojave Desert (see section 2.2) should suffice for ensuring adequate representation of biogeographic variability across the planning area.

Representation goals (defined in Section 4.2.3, below) *for each covered species and community should be established for each subregion, as well as for the entire DRECP area, to ensure* *adequate representation of biogeographic, genetic, and population variability across the plan area.* At the community level, for example, a vegetation type might be well distributed throughout the planning area, but with considerable variation in species composition, climate, and habitat structure among subregions. Consequently, protecting examples of a vegetation type in certain subregions but not others will not capture this range of variation and may not allow for adequate adaptation to climate change. At the species level, a species that is distributed throughout much of the planning region, but in separate populations that vary in size or other characteristics, might be most efficiently conserved in a portion of the plan area supporting the largest and most intact population; however, other populations might be genetically distinct, provide insurance against diseases or catastrophes, be important functional components of a regional metapopulation, or turn out to be the most viable populations under changed climatic conditions.

4.2.3 Identify Areas Important to Conservation, and Areas *Not* Important to Conservation

The conventional approach in modern conservation planning is to conduct a top-down analysis of the planning region to identify and prioritize the most important areas to conserve. This approach is often guided by *representation goals*—or proportions of particular resource types (e.g., community types) to be conserved within a reserve network. The approach is intended to assure that all species, communities, and other features of interest are sufficiently represented in reserve areas to assure their viability. The advisors recommend combining this approach (detailed in the next section, 4.2.4) with an additional "bottom-up" approach of quickly identifying those areas that are demonstrably ***not*** important to achieving conservation goals—i.e., areas that due to previous disturbance are irreversibly converted from potential to support covered species, communities, or important ecological processes (such as wildlife movements). This will allow for the near-term siting of renewable energy developments in areas unlikely to contribute to the conservation of covered species or communities while planning of a more comprehensive, top-down reserve network can proceed. However, we urge diligent application of the Precautionary Principle in identifying such "no-regrets" areas for near-term development. The only areas likely to be unimportant for conservation are areas that have had native vegetation at least partly removed and the soil surface broken (e.g., by grading, grubbing, or tilling) that are also in locations unlikely to contribute to reserve viability or wildlife movement potential. We recommend that the DRECP planners map out areas of current and historical disturbance, verified by field surveys *and compared with existing reserve and linkage maps*, to make this assessment.

4.2.4 Apply Site-Selection Algorithms Wisely

Objective s*ite-selection algorithms* are useful in the top-down reserve selection process because, when used properly, they assure adequate representation of all features in a cost-efficient manner and because they allow transparent development and application of *a priori* representation goals by plan participants and stakeholders. Marxan (Possingham et al. 2000; http://www.uq.edu.au/marxan/index.html) and Zonation (Moilanen et al. 2005; http://www.helsinki.fi/bioscience/consplan/software/Zonation/index.html) are two algorithms that are widely used and have proven useful in diverse planning contexts. During the run of the Marxan algorithm, an initial portfolio of planning units is selected and the total cost calculated.

Planning units are then added and removed and the total cost re-evaluated through multiple iterations in an attempt to improve the total cost and efficiency of the portfolio for the selected conservation targets. The Zonation algorithm starts from the full landscape, and then iteratively discards locations (grid cells) of lowest value from the edge of the remaining area, thus maintaining a high degree of structural connectivity in the remaining habitat. Zonation works particularly well with grid-based inputs, especially those created by species distribution models. Moreover, instead of outputting the optimal set of sites for achieving targets, Zonation outputs the hierarchy of cell *removal* throughout the landscape and species loss curves, which can be useful in quickly identifying areas ***not*** important to conservation and therefore available for siting developments (see Section 4.2.3).

The selection of an algorithm and the associated parameter choices should be justified based on recent standards and peer reviewed literature, especially since this field of conservation biology is changing rapidly. We suggest that DRECP planners experiment with different algorithms before choosing one, and that they perform sensitivity analyses with each algorithm– e.g., vary the quantitative representation goals for various biodiversity features, clustering of planning units (i.e., the boundary length modifier in Marxan), etc., and observe the effect in terms of the pattern and overall area of selected sites in the design. Sensitivity analyses may also provide insight into the uncertainly associated with the reserve selection algorithm and output scenario. The specifications of the parameter settings within an algorithm should be well-documented and justified. In general, we suggest that site-selection algorithms are useful for defining the 'skeleton' of a reserve design, to which planners must apply expert opinion to add the 'flesh.' For example, site-selection algorithms often do not adequately account for connectivity between selected reserve sites, and habitat connectivity areas need to be added to the map.

Regardless of the selection algorithm used, usually some additional analysis is needed to prioritize sites for protection. This is often done by combining two criteria: irreplaceability (or biological value) and vulnerability (or threat) (Margules and Pressey 2000). Irreplaceability is a measure of the relative biological value and distinctiveness of a site. Sites supporting endemic species that occur nowhere else are irreplaceable relative to sites that contain only common or widespread species, for example. At the species level, a site with a high population growth rate, which serves as source population in a regional metapopulation, is irreplaceable; a sink population (where deaths exceed births) is generally not. However, when viewed at a broader spatial or temporal scale, sink populations may play important roles in metapopulation persistence, for example by providing connectivity or "stepping stones" between source populations or by increasing overall metapopulation size and genetic diversity. Also, populations that are sinks in most years may occasionally be sources, therefore enhancing the viability of metapopulation (e.g., Murphy 2002).

Vulnerability at the species level can be measured as the predicted decline in demographic value (e.g., population growth rate) over a period of time if development or other habitat degradation occurs (Carroll et al. 2003). Figure 4, from a study of the Greater Yellowstone Ecosystem, shows how sites might be ranked for conservation priority in terms of their irreplaceability and vulnerability. Sites in quadrant 1 are considered of highest priority for immediate action. However, in the long-term, sites in quadrant 2, being equally irreplaceable on average, are just as important to protect – and are often more intact because they are generally more remote from human population centers (Noss et al. 2002).

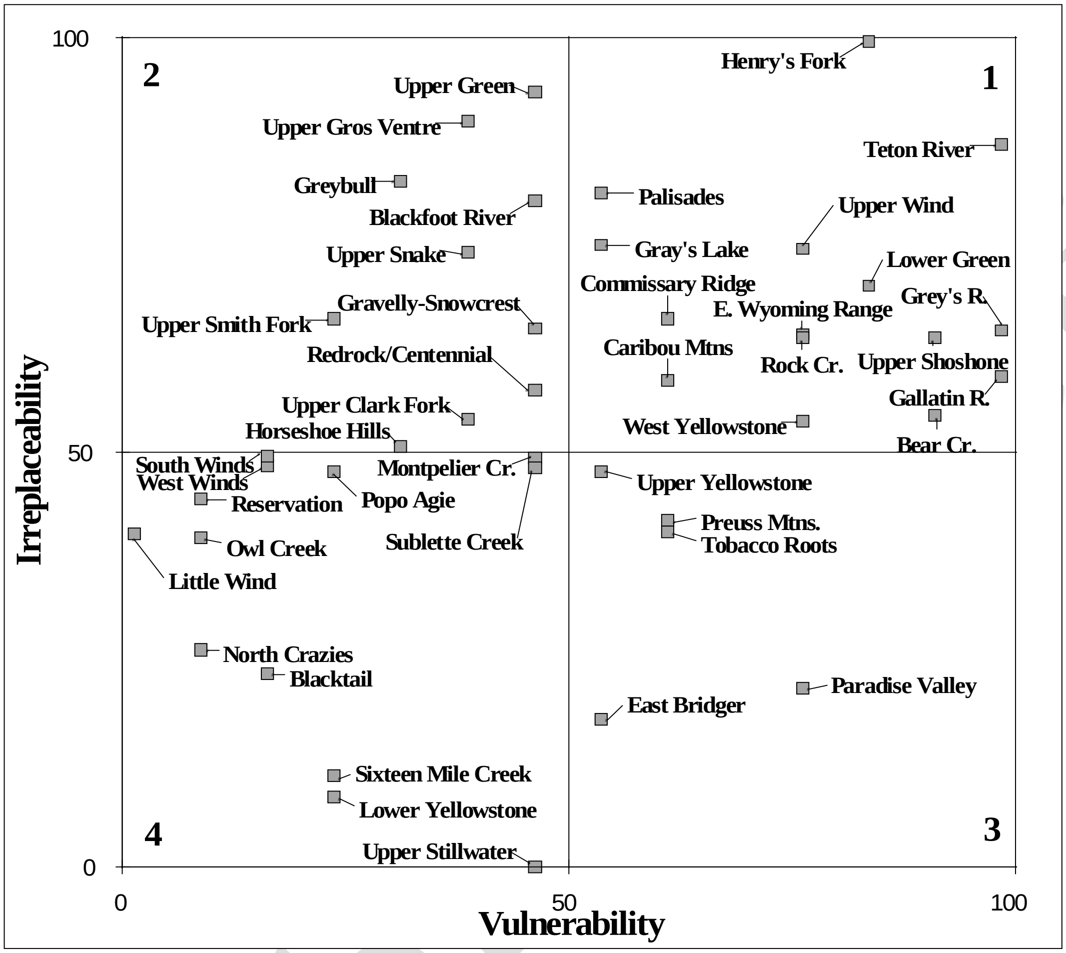

Figure 4. Example of site-specific conservation ranking based on irreplaceability and vulnerability scores. Sites in Quadrant 1 are highest priority for conservation.

Prioritization schemes are most useful in cases where scheduling issues exist – i.e., when it is not possible to protect all important sites at once. In such cases it is urgent to protect the high-value sites that are most threatened. In some conservation plans, including NCCPs, it is possible (at least in principle) to protect most or all biologically valuable sites at once, so such prioritization may not be needed. Nevertheless, if any delays in implementing a plan are anticipated, prioritization should be pursued.

In most conservation plans that apply site-selection algorithms, existing protected areas are "locked into" any conservation solution so that new reserves will add to the existing system rather than replace it. Hence, we recommend that top-down conservation planning for the DRECP start with the existing system of reserves (all categories) and build on it by adding new reserves, buffers, and connectivity. Importantly, the design must be based, to a large extent, on existing distributions of species, communities, and other features. However, it must also be able to accommodate shifts in species distributions with expected climate change. Hence, reserve system should protect a full range of enduring features and physical and ecological gradients

(Section 2.9) within contiguous and interconnected areas. Such a reserve system will provide species maximum opportunities to shift their distributions over time.

We suggest that the following elements are essential conservation targets, for which high representation goals should be established (i.e., approaching 100% in some cases):

- Unique Plant Assemblages as identified in Section 2.4.1.
- Special Features, as identified in Section 2.7.
- Areas of known importance to key covered or planning species, including at least the following:
  - desert tortoise critical habitat
  - bighorn populations and linkages
  - “core populations” and hypothesized linkages for Mohave ground squirrel
  - populations of species that are endemic or near-endemic (e.g., over 75% of total distribution) to the planning region
  - known habitat or populations of other species that are determined to be at high risk of extinction within the planning region
- Linkages between core habitat areas identified by any of the following: the California Desert Connectivity Project (Penrod et al., in preparation), South Coast Missing Linkages Project (Beier et al. 2006, South Coast Wildlands 2008) and California Essential Habitat Connectivity Project (Spencer et al. 2010).
- Habitat predicted to be essential to accommodate distributional shifts, in response to climate change, as predicted based on existing (e.g., Wiens et al. 2009) or future models.
- Areas important to maintaining dynamic geological processes, including eolian sand sources, wind corridors, and settling areas.
- Hydrologically important areas (e.g., washes, groundwater recharge areas, springs, seeps, etc.), including first- through fourth-order washes and washlets.

Regardless of the precise inputs, goals, and algorithms used, site-selection algorithms must be applied in a transparent and easily understandable manner. Use of algorithms must be augmented by attention to reserve design principles, and expert knowledge on species life histories, ecological processes, and other factors that determine viability of species and sustainability of ecosystem functions.

4.2.5 Use Planning Species and Other Key Surrogates to Derive Specific Design Standards

Many conservation planning efforts have applied general rules or principles (e.g., “bigger is better,” “connected is better than unconnected,” “corridors should be wide rather than narrow”) that are difficult to apply in practice because they lack specificity. Only through intelligent consideration of the life histories of particular species, the distribution of physical environmental features, and the operation of key natural processes can conservation plans move beyond simple generalizations. We recommend the use of focal or planning species (see section 2.6, above) to help derive more realistic and specific reserve design standards. In addition, natural processes, such as wind, hydrology, and fire (in areas with historic fire regimes) can be useful as surrogates for reserve design, with the goal being to maintain a spatial configuration of habitats that allows for natural operation of these processes.

4.2.6 Provide Large, Well Distributed Core Areas, but Don't Ignore Important Small Areas

Arguments in the academic literature about whether it is better to have fewer large reserves or more small reserves have died down with the recognition that the question is a red herring–it depends on the species and other case-specific details, and almost never will a conservation planner have to decide between one or the other (Soulé and Simberloff 1986, Noss and Cooperrider 1994). All else being equal, reserves should be as large as possible, because larger reserves have more resources, higher species richness, and larger populations that are less vulnerable to extinction; larger reserves are also less vulnerable to edge effects and other threats that cross reserve boundaries. However, many natural features (e.g., a spring or isolated dune) are small but nevertheless irreplaceable. They should be buffered, when possible (see below), but certainly not ignored simply because they are small.

An important consideration in determining necessary reserve size is the area requirements of the species of conservation interest that inhabit the area. Different species have different area requirements, with large-bodied carnivores generally requiring the largest areas (Woodroffe and Ginsberg 1998). We recommend that planners for the DRECP identify the most area-limited focal species (see Section 2.6) for each major vegetation type as a guide, the objective being to create reserves large and/or connected enough (see below) to maintain viable populations of all of those species.

4.2.7 Buffer Reserves with Compatible Land Use

The concept of surrounding reserves with buffer zones of appropriate, low-intensity land use goes back at least to the seminal work of ecologist Victor Shelford in the 1920s through 1940s (Croker 1991) and later incorporated into the biosphere model (UNESCO 1974) and adapted to reserve design in diverse landscapes (Harris 1984, Noss and Harris 1986, Noss 1987). Although well accepted by conservation biologists, the buffer zone idea has not always been politically palatable (i.e., it is seen by some as a sneak attempt to enlarge reserves; Noss, pers. obs.), nor have established buffer zones been easy to defend. Nevertheless, the concept remains valid, and establishment of the buffer zones is even more defensible and urgent during the present period of rapid climate change and shifting species distributions. The details of buffer zones (e.g., how wide they need to be, what land uses are permissible, are they considered part of a reserve or a separate, outside zone) are again highly case specific, depending on the particular species and resources that are expected to benefit from buffering, the size and habitat quality of the core area that is being buffered, the nature of the surrounding matrix, land ownership and land use issues, and other factors. There may be no substitute for highly skilled expert opinion in determining buffer zone requirements, although a well-designed adaptive monitoring program (Section 6) should supply empirical data over time to better justify and refine buffer requirements.

4.2.8 Connect Reserve Areas and Provide for Wildlife Movement

Habitat fragmentation and disruption of wildlife movements are great threats to covered species. Connectivity needs are species- and landscape-specific, and approaches based on the requirements of a wide range of focal species are generally most defensible (Beier et al. 2006, 2008; Spencer et al. 2010). Although it is important to select and plan for the needs of those focal species that are most sensitive to habitat fragmentation and movement barriers, it is also important to consider the different movement modes and constraints of diverse taxa. Although large carnivores are often assumed to be ideal focal species for designing corridors, corridors designed for them may not provide adequate connectivity for other wildlife (Beier et al. 2009). Some species that are not particularly wide-ranging (e.g., many reptiles or small mammals) are appropriate focal species for designing linkages, in part because they may be more likely than larger animals to avoid roads or be killed on roads. And, although birds are often neglected in connectivity plans because most can fly over unsuitable areas, some birds are highly susceptible to fragmentation effects and are useful for connectivity planning—such as roadrunners, quail, or other birds that mostly travel on the ground or fly only short distances.

Rigorous tools are now available for designing, assessing, and comparing linkage designs and movement corridors (Beier et al. 2008, McRae and Beier 2007, McRae et al. 2008, Spencer et al. 2010) and for incorporating uncertainty into corridor designs (Beier et al. 2009). However, rather than starting from scratch, *we recommend that DRECP review, incorporate, and build on previous connectivity work in the planning area. Specifically, the following references should be consulted by DRECP, and their results used to help with DRECP reserve design:*

- California Essential Habitat Connectivity Project (CEHC; Spencer et al. 2010),
- California Desert Connectivity Project (Penrod et al., in preparation),
- South Coast Missing Linkages Project (SCML; Beier et al. 2006, South Coast Wildlands 2008),
- Likely bighorn sheep movement corridors (Epps et al. 2007).

The California Desert Connectivity Project (Penrod et al., in preparation) provides the most comprehensive and detailed connectivity analysis available for the DRECP planning area. Results of this project—including least-cost corridor models for diverse focal species and detailed, multi-species linkage designs using the methods described in Beier et al. (2006)—should be incorporated into the DRECP reserve design following peer review and refinement, as needed. The goals of the Desert Connectivity project are to identify the most important areas in need of conservation and management to sustain and improve habitat connectivity and movement potential between large core areas (mostly large habitat areas on public lands) throughout California's deserts. The process included using an expert workshop—attended by numerous scientists, conservationists, and land managers from governmental and nongovernmental organizations—to identify large habitat areas in California's deserts that are most in need of connectivity and to select diverse focal species whose movement and habitat needs should be accommodated by landscape linkages. The experts identified 47 important linkage areas, which were objectively rated using a consensus scoring procedure to rank their biological irreplaceability (value) and the relative degree of threat to their functional connectivity (see section 4.2.4). This ranking process was used to prioritize 23 linkage areas for detailed modeling and linkage design, based on the habitat and movement needs of 48 focal species (10 reptiles and amphibians, 13 mammals, 11 birds, 9 plants, and 5 invertebrates).

Least-cost corridor models (Beier et al. 2006, 2008) were then developed between habitat and population core areas for each species. These single-species linkages were then composited (using a GIS "union" function), further assessed for their ability to support populations and movements of focal species, and buffered (following methods described by Beier et al. 2006) to develop 23 robust, multi-species linkage designs intended to ensure functional connectivity for all focal species. Detailed management and monitoring recommendations are being developed for each linkage area, which includes identifying specific locations and design criteria for wildlife crossing improvements, such as road-crossing structures (e.g., wildlife underpasses or overpasses), wildlife fencing, and other measures to reduce roadkill and improve population connectivity.

The South Coast Missing Linkages (SCML) project (Beier et al. 2006, South Coast Wildlands (2008) preceded the Desert Connectivity Project (Penrod et al. in preparation), which expanded the geographic area from California's South Coast Ecoregion across California's desert ecoregions. SCML developed several linkage designs that connected portions of the South Coast Ecoregion with the Mojave and Sonoran Desert Ecoregions, and thus several linkage designs prepared for SCML are partly within the DRECP plan area and should be incorporated (see Appendix G for hyperlinks to appropriate SCML linkage reports). The Desert Connectivity Project was designed to be complementary to SCML, using similar analytical tools; *and together all existing linkage designs from these two projects that are in or partly within the DRECP area should be incorporated into the DRECP conservation design*.

The California Essential Habitat Connectivity Project (CEHC; Spencer et al. 2010) was coarser in scale than the Desert Connectivity Project or SCML, and did not use focal species to identify areas needing connection (instead, it used indices of environmental integrity and other biological inputs to identify large "Natural Landscape Blocks" and "Essential Connectivity Areas" throughout California). We do not recommend relying on maps from CEHC as *primary* inputs for site-specific reserve design in DRECP—due to coarse resolution, data constraints, and resulting errors of omission from the Natural Landscape Blocks and Essential Connectivity Areas, *especially in the deserts* (Spencer et al. 2010, page 41). The finer-resolution, focal-species maps produced by Penrod et al. (in preparation) and South Coast Wildlands (2008) are more defensible for DRECP reserve-design purposes. Nevertheless, we recommend considering the Natural Landscape Blocks and Essential Connectivity Areas identified by the CEHC as additional important areas to conserve, particularly where they lie outside of conservation priority areas not already conserved or mapped by other efforts.

More importantly, CEHC is an important source of information and guidance for how to maintain and improve habitat connectivity, wildlife movement, and adaptation to climate change. It provides a comprehensive and stepwise review of how to develop detailed regional and local linkage plans, wildlife crossing structures, and other conservation actions to counter fragmentation and climate change effects on ecological communities and species. It also addresses methods for incorporating climate change adaptation into linkage designs, such as the land-facets approach of Beier and Brost (2010).

Additional Linkage Planning. Although the existing linkage plans discussed above provide a solid starting point for addressing habitat connectivity in DRECP, we emphasize that *these efforts should not be used uncritically, but should be reviewed, refined, and built upon as needed to meet plan goals*. Additional linkage designs, for additional focal species or areas of concern, may be required to supplement existing designs. Spencer et al. (2010) detail step-by-step processes for preparing such designs. In addition, they stress the importance of *recognizing all riparian areas and washes as important linkage features* (which is especially true in light of climate change: Seavy et al. 2009) regardless of their location inside or outside of natural habitat blocks or reserve areas.

4.3 Siting, Configuring, and Mitigating Renewable Energy Developments

Renewable energy developments may contribute to loss, fragmentation, and deterioration of plant and animal populations and habitats; changes in above and below ground hydrology; and increases in roads, vehicular traffic, subsidized predators, light pollution, dust, and human populations locally and regionally. The extent of the negative impacts depends on the type, location and size of the development, as well as how the energy is transmitted off-site. Some negative impacts from development will spill over onto adjacent lands and may have impacts far beyond the footprint of the developed site. Also, as introduced in Section 2.10, different types of renewable energy development will have different sorts of impacts, and therefore different siting and mitigation guidelines.

4.3.1 General Guidance for All Covered Actions

In general, the advisors recommend adhering to the strict sequencing of “avoid, minimize, and mitigate” for impacts to biological resources and ecosystem processes. Preference should always be given to avoiding impacts to undisturbed habitat areas and siting developments on already disturbed areas, so long as siting a development in a previously disturbed area won’t disrupt important ecosystem processes, such as wildlife movements, water flows, or eolian sand transport and dune dynamics. Where strict avoidance of new disturbance is not possible, project siting and design should strive to minimize impacts to native vegetation, undisturbed soils, wildlife movement, or other important resources and processes. Finally, unavoidable impacts should be mitigated by appropriate actions.

The following recommendations apply to all covered actions:

- Site developments to the greatest extent possible on already disturbed lands (where vegetation has been altered and soil surface broken or disturbed), such as fallow agricultural fields, brownfield sites, industrial sites, and scattered private and public lands within and adjacent to cities and towns. Such sites are readily available throughout the Mojave and western Sonoran deserts. We also of course endorse “roof-top” or distributed solar development in urban areas to maximize power production from sites with little or no biological value.

- Site developments as close as possible to and use existing transmission line corridors and rights-of-way as a high priority. "Bundle" or co-locate linear facilities immediately adjacent and parallel to one another to avoid new fragmenting effects. Be aware in some cases that this make an existing partial barrier to wildlife movement even worse, but in most cases this is likely better than creating new fragmentation. Mitigate adverse effects of linear features on wildlife movement by creating safe crossing areas through existing, new, or bundled groups of linear features

- Avoid any developments within critical habitats for federal and state-listed threatened and endangered species; candidate species for federal or state-listing; sensitive habitats, core areas, and important linkages, migration corridors, or habitat connectivity areas (Spencer et al. 2010, South Coast Wildlands 2008, Penrod et al. in preparation, Epps 2007); or in designated Natural Areas, Research Natural Areas, Areas of Critical Environmental Concern, and Wilderness.

- Minimize the impact footprint of a development to the maximum extent possible, recognizing that the impact footprint may be larger than the actual development or construction footprint. For example, wind energy projects are often characterized as having relatively small project footprints, because the turbines themselves disturb small areas of ground. However, in assessing ecological footprints it is important to include all components necessary for a viable project (e.g., access roads and transmission lines). Include offsite effects, such as interruption of sheet flows that support downslope vegetation or interruption of blowing sands that support active dune systems.

- Avoid contributing to habitat fragmentation adjacent to or in the proximity of reserve areas or important habitat areas, including National Parks, ACECs, Wilderness Areas, etc. In many cases, the original boundaries of sensitive environmental areas were based on such factors as land ownership and politics, rather than on principles of reserve design or on maintaining viability of an ecosystem. Siting a renewable energy project with associated transmission lines adjacent to a protected area has high potential for fragmenting the landscape.

- Fence highways and roads providing access to renewable energy sites with appropriate animal-proof fencing to reduce illegal collection and road kills of wildlife, and to reduce food sources of subsidized predators. Special wildlife crossing structures (e.g., underpasses and overpasses that facilitate movements of animals) may be necessary for sites that are not located in or adjacent to towns and cities. The type of wildlife crossing and fence will depend on the focal species of concern. See Boarman (1995) and Boarman et al. (1997) for effectiveness of fences and culverts for protecting desert tortoises along highways, and Spencer et al. (2010) and references therein for general guidance for siting and designing wildlife crossing structures.

- Reduce light pollution by minimizing the number and intensity of lighting units and directing any light away from habitat areas.

- Fence artificial water sources, such as evaporation ponds, and cover them to reduce subsidies to predators (e.g., coyotes and ravens) and to prevent birds, bats, and other animals from becoming entangled, ill, or otherwise harmed by the fluids.

- Minimize dust and sand generated by construction and by travel on dirt roads. Avoid producing deposits and accumulation of eolian sands adjacent to and downwind from the site, because such surficial materials provide seed beds for alien plants and cause habitat deterioration.

- Restrict temporary construction disturbances, such as lay-downs and access routes, to existing roads and disturbed areas.
- Develop and implement a long-term program to eliminate alien annual plants in and near project sites, access roads, and transmission line corridors and other areas used to transmit power.
- Develop and implement a long-term program to prevent trash and food scraps associated with the facility, contractors, and employees from becoming distributed beyond closed receptacles at the site. Trash must not be allowed to blow out of or away from the site and access roads and become distributed on the landscape. Trash has a negative effect on wildlife and may draw in undesirable species or aggregate species in disproportionate numbers (such as ravens). Collect any trash that blows off-site.
- Evaluate growth-inducing and cumulative impacts as part of environmental analyses, minimization and mitigation measures, and permit requirements.

4.3.2 Linear Infrastructure

- Minimize the total length of new (and temporary) roads, transmission lines, or other linear structures to the degree possible by siting energy projects near existing infrastructure, and avoid bisecting undisturbed desert habitats or crossing preserve areas. "Bundle" or co-locate new roads and transmission lines within existing easements and transmission line corridors, and retrofit existing transmission lines to carry additional electricity, or site new rights-of-way along other existing linear features, such as canals, roads, and aqueducts.
- Site, design, and construct appropriate crossing structures for wildlife across roads, canals, and other linear barriers or filters to wildlife movement. See Spencer et al. (2010, pages 141-146) and references therein (especially Meese et al. 2009, Clevenger and Huijser 2009, and http://www.wildlifeandroads.org/) for detailed reviews of road mitigation measures and recommendations for siting, designing, and implementing crossing structures, fences, and related measures. In addition, see Brooks (1995, 2000), Boarman (1995), and Boarman et al. (1997) for information on the effectiveness of fencing and culverts as mitigation measures for desert reserves and desert tortoises.
- Where new or refurbished transmission lines cross desert habitats, evaluate whether undergrounding can be used to minimize impacts. Undergrounding may not be desirable, because this could alter hydrological or other overland flow processes. Conduct pilot tests with appropriate Before/After-Control/Impact (BACI) sampling designs (see Section 6.4) to compare the relative impacts of different transmission designs (e.g., elevated vs. undergrounded) on biological and geohydrological resources.
- Use deterrent devices to discourage perching by ravens and raptors (Slater and Smith 2010) on transmission lines, towers, or other structures.

4.3.3 Solar Projects

The main impact of solar projects on biological resources is the direct removal, degradation, and fragmentation of habitat areas, although there are also concerns about indirect impacts and potential mortality of birds and insects from thermal concentrating facilities (Section 2.10.3).

- Site solar energy facilities on previously disturbed lands such as old or abandoned agricultural fields, areas scraped or bulldozed for development of tract housing, lands cleared of native vegetation and zoned for light industry, and lands within or on edges of cities, towns, and existing settlements on valley floors.
- Study the possibility of siting solar projects in long, narrow, linear arrays along existing roads (e.g., in interstate medians?), canals, or other linear features that already represent barriers to wildlife movement or major habitat fragmentation features. This will minimize new fragmentation effects. Mitigate the combined effect of any new developments and existing features with wildlife crossing features, including occasional wide gaps in developments, coupled with appropriate wildlife crossing structures (e.g., wildlife overpasses, underpasses, or bridges to accommodate road crossings) and appropriate wildlife fencing to funnel animals to the crossing location.
- If necessary, fence solar facilities with animal-proof exclusion fencing to protect against entrapment and mortalities, but mitigate for disruption of wildlife movement potential by improving wildlife crossing areas elsewhere (e.g., by providing road crossing structures for wildlife in other locations).
- Avoid siting on playas, playa margins, high-slope alluvial fans or bajadas, and old geologic surfaces armored with desert pavement because of the high potential for dust pollution and disruption of hydrological regimes. Site solar energy facilities on low-slope fan aprons out of eolian transport zones and preferably in previously disturbed landscapes.
- Avoid siting near habitats that concentrate birds and other desert wildlife, including all wetlands, major washes, oases, etc.
- Mitigate the confusing effects of polarized light reflections from solar panels on wildlife species that may mistake them for water bodies or that otherwise use polarized light as behavioral cues by experimenting with and applying cell borders or grids that break up the reflections, as described by Horvath et al. (2010).

4.3.4 Wind Projects

Although the direct impact footprint of wind turbines are relatively small, like all projects their ancillary features, including roads, transmission lines, etc., increase both the direct and indirect impacts. Wind turbines also can directly kill numerous birds and bats, which is one of the major concerns.

Fortunately, good guidance already exists for siting turbines and mitigating for and monitoring their effects. New federal guidelines for minimizing adverse effects of wind turbines on wildlife were recently released (too recent for review in this report) by the USFWS Wind Turbine Advisory Committee. In addition, the California Guidelines for Reducing Impacts to Birds and Bats from Wind Energy Development (CEC and CDFG 2007) provide relevant, science-based guidance for siting of wind energy developments in California. They provide relevant guidance for pre-construction and operations monitoring of bat and bird activity levels, fatality monitoring during operations, siting recommendations at the facility and turbine level, and approaches to mitigation. The Guidelines were completed following a stakeholder process facilitated by CEC and CDFG and have been vetted by conservationists, developers, and other interested parties to arrive at a set of mutually acceptable standards. Although new information gathered during implementation of wind-energy developments should continue to improve on these guidelines, they provide the best available guidance on monitoring and mitigation and should be used by DRECP.

Especially important is a recommendation in the Guidelines to archive results of pre-construction and operations monitoring efforts in an accessible database. This recommendation applies to all proposed sites within the DRECP planning area, whether they become operational facilities or not. Over time, such a database has the potential to promote adaptive learning regarding the linkage between pre-construction surveys and fatality rates of bats and birds at operational facilities. In addition, it may help to suggest thresholds for what should be considered high levels of activity or sites which pose greatest risk to birds or bats.

As part of pre-construction monitoring for siting new or repowered turbines, study the flight and foraging behavior of condors and other raptors relative to terrain, wind, and other factors. Research has shown, for example that repowering older wind turbines in the Altamont Pass Wind Resource Area (central California) with fewer, taller turbines reduced mortality rates for large raptors like golden eagle and redtailed hawk, although it may have increased bat mortality rates (Smallwood and Karas 2009). Switching to single pole (as opposed to open lattice) tower structures, and sealing all openings that birds can enter or use for nesting, has reduced perching and nesting by birds on the towers, further reducing mortality rates. Avoiding the siting of turbines in ridge saddles or other terrain features that tend to concentrate flight paths can also reduce impacts (Smallwood et al. 2009).

Evaluate temporal avoidance to further minimize potential impacts at both the facility-and turbine-level (CEC and CDFG 2007) by defining when impacts occur, and under what environmental conditions (e.g., time of day, season, wind speed, and temperature). Intensive (e.g., daily) ground searches for bird and bat mortalities during selected periods could provide sufficient data resolution to evaluate these factors. Using this information, it is possible to fine-tune turbine operations to reduce mortalities. For example, recent research demonstrating that bat activity and fatalities were highest on nights with low to moderate wind speeds (Arnett 2005, Arnett et al. 2006, Weller 2008) has led to mitigation experiments where cut-in speeds of turbines have been raised to reduce bat fatalities. These mitigations have led to >50% reductions in bat fatalities with minimal changes to power output (Arnett et al. 2009, Baerwald et al. 2009).

4.3.5 Guidelines for Improving Effectiveness of Mitigation

Numerous mitigation actions to offset adverse development impacts to plants and animals have been tried, but the successes and failures of various approaches are poorly documented and few publications are available concerning the effectiveness of alternative mitigation measures for biological resources in the California deserts. Some information is available on the value of fenced and protected preserves (e.g., Brooks 1995, 2000). Data are also available on effectiveness of highway fencing and use of culverts to protect desert tortoises (Boarman 1995, Boarman et al. 1997). However, much more needs to be done within a scientific framework on such topics as control of invasive and established alien plants, recovery of native annual and perennial vegetation after disturbance, and control of subsidized predators.

We recommend that *DRECP encourage and potentially fund a research project by an appropriate academic or research institution to review the history and effectiveness of various mitigation and conservation actions in California*. The objectives of the document should be to identify what works and what has not, to recommend possible solutions, and to advance the state-of-the art in mitigating and off-setting the effects of development, especially with regard to renewable energy projects. The compilers of this document should work with employees in state and federal agencies associated with protection and management of public and private lands, non-profit corporations involved in acquiring and protecting land and implementing mitigation measures, and law enforcement personnel actively engaged in protecting habitat and wildlife. This compilation should focus on what can be done to improve conservation and mitigation efforts. Some individuals may be reluctant to speak about failures. Nevertheless, failures should be identified and used as a means of improving the mitigation and compensation process.

One action that we generally do ***not*** endorse as mitigation *per se*—except perhaps under certain rare circumstances where scientific evidence suggests it may be warranted—is animal translocations out of proposed development areas into reserve areas. This is often done but rarely effective—a “feel-good” measure that has dubious ecological benefits and potential to do more harm than good. Although carefully designed translocations can be useful under certain circumstances—such as reintroducing a species to former areas of occupancy, given that the reason for their original extirpation has been rectified—simply moving animals from one area to another (likely already occupied) area is not recommended. In all cases, such extraordinary actions as translocations, reintroductions, or predator control should be treated as adaptive management experiments, with appropriate monitoring to ascertain their effectiveness and to maximize information gained from the experiment.

5 Additional Principles for Conserving Select Covered Species

Previous sections of this report provide comprehensive approaches for conserving covered species and communities via avoidance, minimization, and mitigation measures and a broad, landscape-level approach to designing a reserve network for desert biota. This section provides some additional information pertinent to conserving and managing particular species or groups of species, over and above recommendations in earlier sections. This information should be seen as supplemental to a comprehensive, multi-species, multi-community approach to conserving and managing a broad, landscape-level reserve network to sustain desert communities now and into the future.

- **Mohave Ground Squirrel.** We advise following recommendations currently being prepared by the Mohave Ground Squirrel Technical Advisory Group (MGS TAG), a long-standing committee of MGS technical experts from the private sector, academia, and land management and regulatory agencies. The TAG has drafted MGS conservation priorities based on recommendations made by Leitner (2008) and modified based on more recent information and expertise of TAG members. The document is currently in review by TAG members, with a goal of producing a final, consensus document as early as September, 2010 (S. Osborn, CDFG, MGS TAG Chair, personal communications). In the meantime, the DRECP advisors generally endorse the following recommendations from P. Leitner (2008, and personal communications) concerning conservation priorities for Mohave ground squirrel: (1) maintain connections between known population areas and avoid siting developments in known population areas or potential connectivity areas; (2) establish buffer zones of at least 5 miles (8 km) around four identified “core” population boundaries, avoid developments in these buffer zones, and manage them to protect colonizing juveniles; (3) acquire private inholdings within these delineated core populations; (4) restrict off-highway vehicle (OHV) use to designated routes within BLM lands in core areas; (5) conduct additional surveys to identify new population areas and improve understanding of potential connecting habitats. In general, the advisors do ***not*** recommend translocation or captive breeding as effective mitigation or conservation actions for Mohave ground squirrel (or most covered species). Natural history characteristics of MGS make them particularly poor candidates for translocation or captive breeding, and *in situ* habitat conservation and management is far superior to attempting to move animals to new locations or to bolster existing populations. If translocations are attempted, they must be treated as experiments, with intensive and long-term monitoring of populations to determine their effectiveness and improve scientific understanding of the species.

- **Desert Tortoise** (*Gopherus agassizii*). The advisors recommend that DRECP review and implement appropriate conservation, mitigation, and recovery actions outlined in the Desert Tortoise Recovery Plan. The desert tortoise is a widespread species (Nussear et al. 2009) whose numbers have declined for decades and continue to do so (USFWS 1994) due to a variety of anthropogenic activities (USFWS 1994, Tracy et al. 2004). Tortoise populations are susceptible to losses from disease (Jacobson et al. 1994, Homer et al. 1998, Brown et al.

1999, Christopher et al. 2003) drought (Berry et al. 2002, Longshore et al. 2003) and predation (Esque et al. *In Press*) and are slow to recover. Little empirical data are available about the dispersal and survival of young desert tortoises, although adult tortoise movements have been observed for decades. Desert tortoise home ranges are known to range from 4 to 40 ha or more, and movements of up to 20 km have been recorded. There is one published record of movements in excess of 30 km from the Sonoran Desert (Edwards et al. 2004). Thus relatively short dispersal distances coupled with long life-spans likely mean that isolation by distance is a primary mechanism for population differentiation (Murphy et al. 2007, Hagerty and Tracy 2010). Based on landscape genetics analyses, connectivity among desert tortoise populations has been primarily affected by mountain ranges and extremely low elevation valleys (Hagerty et al. *In Review*). Disturbances caused by linear features or activities that block landscape pinch points have "likely removed all possible paths among previously connected populations" (Hagerty and Tracy 2010). Connectivity among populations may also be affected by factors causing localized extinctions. As with the Mohave ground squirrel, the advisors do ***not*** recommend translocation of desert tortoise as effective mitigation or conservation action, in part because translocated tortoises suffer high mortality rates. We do endorse implementing roadside fencing to reduce roadkill and road undercrosses to improve population connectivity, as called for in the Desert Tortoise Recovery Plan.

- **Bats**. Basic conservation needs of bats are met by ensuring that roosts, foraging areas, and free water are maintained within a few km of one another. However species of bats differ in the types of structures used as roosts, types of habitat favored for foraging, and nightly distances travelled to reach foraging and drinking areas. Therefore, conservation and mitigation efforts must take care to ensure that proposed actions are species-specific and maintain viable juxtaposition between important resources. For instance, loss of cave roost habitat in one area cannot be mitigated via protection of rock face or tree roost habitat elsewhere, as it would be unlikely to be used by the affected species. Similarly, loss of roost habitat cannot be offset through provision of foraging habitat. The success even of in-kind (e.g., protection of foraging habitat to offset loss elsewhere) habitat substitution should be verified through an adaptive management process before it is widely implemented as a mitigation tool.

  In addition, bats must be able to move freely between seasonal habitats to reach mating and birthing areas. Evidence to date suggests that bats are most vulnerable to collision mortality with wind turbines during these seasonal movements (Arnett et al. 2008). These conclusions were based largely on impacts to tree roosting bats at latitudes further north than the DRECP planning area. However recent monitoring results at a wind energy facility within the DRECP planning area suggest that timing of impacts may be similar (e.g., during spring and fall migration periods) even if the species involved differ (Chatfield et al. 2009). Effective conservation of bats that migrate seasonally should ensure that steps are taken to minimize collision mortality at wind energy facilities.

6 Principles for Adaptive Management and Monitoring

Adaptive management is a systematic process of using advances in scientific knowledge to continually improve management practices by learning from outcomes of previous actions. An Adaptive Management and Monitoring Program is a mandatory component of an NCCP/HCP, and a carefully designed management and monitoring program is essential to success of any conservation plan. Often, however, this crucial component is addressed near the end of the planning process, almost as an afterthought once the conservation design and mitigation measures are established. We recommend an alternative strategy of developing key aspects of the Adaptive Management and Monitoring Program up front. In essence, *DRECP should be treated as a huge environmental experiment that should be developed and implemented incrementally in an adaptive management framework—with continuous monitoring and scientific evaluation to reduce uncertainties and improve plan actions over time*.

The advisors strongly recommend the following Principles to guide the statutorily required Adaptive Management and Monitoring Program (AMP), which we expand on in following sections:

- **Timing:** *Begin monitoring studies, and implementing adaptive management actions, immediately—during planning—to reduce uncertainties about plan outcomes and inform future plan decisions.*

- **Institutional structure:** *Develop a formal institutional structure that ensures strong, effective feedback from monitoring and research studies to plan decisions, and use this structure to continually improve all aspects of the plan over time, during both plan development and implementation.*

- **Hypothesis-based monitoring:** *Use conceptual and quantitative models that formalize understanding of the systems of interest to guide development and testing of hypotheses with monitoring studies.*

- **Appropriate monitoring design.** *Use robust statistical sampling designs for monitoring programs to maximize reliability of resulting data, including (1) Before/After-Control/Impact designs for new energy developments and (2) systematic surveys across the plan area to better establish landscape-scale baseline conditions.*

- **Focused research studies.** *Implement focused research studies to address uncertainties about how to sustain covered species and communities, such as landscape genetics and demographic studies to determine where conservation actions are most needed to sustain populations in the face of habitat fragmentation and climate change.*

6.1 Implement Monitoring and Adaptive Management Immediately

Typically, adaptive management and monitoring plans have been developed as final steps in NCCP and HCP planning, with monitoring recommendations developed almost as an afterthought once the conservation plan is drafted, or even after an implementing agreement has been signed (personal observations of advisors). Given uncertainties about the impacts of diverse renewable energy developments and associated infrastructure on covered species and communities, DRECP should reverse this typical approach by *immediately developing and implementing monitoring protocols and securing access to lands proposed for renewable energy development*. Researchers from governmental and nongovernmental research institutions *must have access to lands proposed for development before, during, and after construction and operation of energy developments and appurtenance structures.* Access prior to construction is necessary to characterize ecological baseline conditions in and near proposed developments and thus allow Before/After—Control/Impact (BACI) sampling designs (Green 1979). BACI designs allow for much stronger inference about impacts of developments on biological resources than the “after-the-fact” monitoring typically implemented by conservation plans. Results of these studies should be used to evaluate impacts during and after construction, and use the results to inform future developments. Moreover, the plan should initiate some systematic, landscape-scale sampling across the study area to better characterize baseline environmental conditions prior to implementation of large-scale energy developments and further climate change. These recommendations are expanded on in Section 6.4.

The advisors recommend obtaining additional scientific input as soon as possible to assess monitoring priorities, metrics, sampling designs, and related matters to implement at renewable energy projects permitted during within the coming months or year. Solid baseline sampling should occur as soon as possible, prior to any construction. Monitoring designs and protocols can be modified over time, but it is essential that initial sampling is robust to any likely changes to ensure comparable data over time. Detailed monitoring recommendations were beyond the scope of this science advisory report, given available time.

6.2 Framework and Institutional Structure

In concept, adaptive management is a strong and scientifically sound approach for improving plan actions by “learning as you implement.” Unfortunately, however, it is almost never successfully applied due to weak institutional structures that fail to ensure that accumulating scientific information—whether data collected within the plan from monitoring studies, or information from outside the plan from research studies—is actually applied to refine actions and make the plan truly adaptive. Lack of clearly defined and enforced institutional processes, and a failure to assign, fund, and empower the necessary personnel, are typical. Independent Science Advisors for the Sacramento-San Joaquin Bay Delta Conservation Plan (BDCP) tackled this problem for that plan based on their collective experience with both failed and successful AMPs for other large, complex conservation and restoration plans around the world (Dahm et al. 2009). We urge DRECP to develop an institutional structure similar to that recommended by Dahm et al. (2009) as illustrated in Figure 5. This structure, along with more detailed guidance provided by Dahm et al. (2009) represents a vast improvement over the often vague and weak structure s that generally doom AMPs to fail. It should be adapted and refined as necessary to fit the

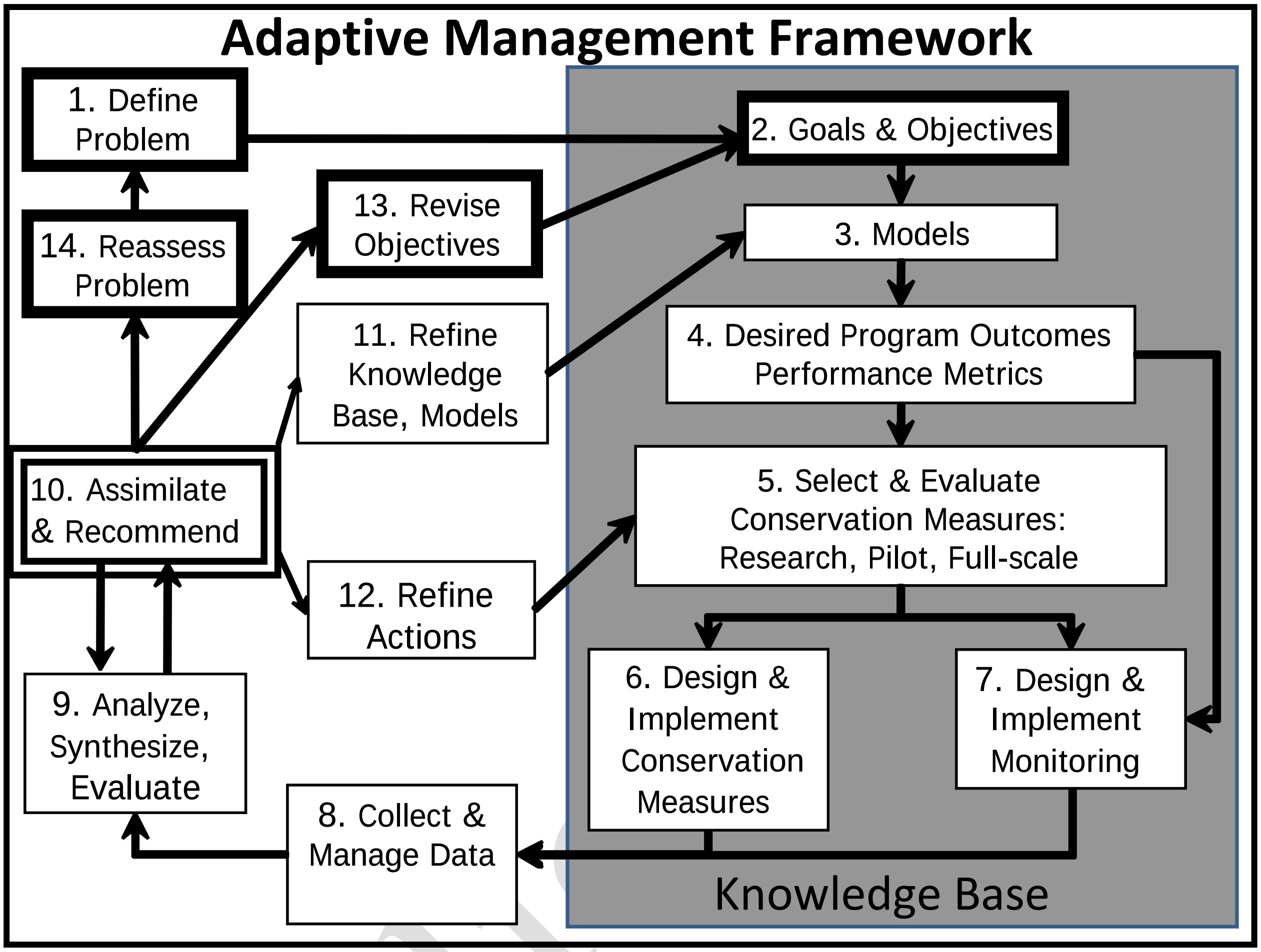

Figure 5. *A recommended AMP framework showing the flow of information and responsibilities of different entities.* The large shaded box underlying the right side of the figure represents the knowledge base for defining goals and objectives, designing predictive models, predicting outcomes, identifying performance metrics, and designing and implementing conservation measures and monitoring actions. Boxes framed with thin lines represent tasks performed by technical staff, such as scientists, land and water managers, and other analysts. Boxes framed with bold lines represent tasks performed by senior decision makers (i.e., policy makers and program managers who control program objectives and funding). The box framed with double lines (Box 10) represents a key step that is missing from most AMPs: Assimilate and Recommend. This task requires a body of skillful "polymaths" who understand both the technical and policy implications of the information passed along by technical staff (who analyze, synthesize, and evaluate monitoring and other data; Boxes 8 and 9). The task represented by Box 10 is to assimilate this diverse information, understand its consequences, and formulate recommendations to both the senior decision makers and the technical staff, such as revising plan objectives or conservation measures (Dahm et al. 2009).

particular needs of DRECP. For example, there should be a well-defined and enforced process for amending existing land-use and preserve management plans in California's deserts based on the DRECP conservation design and mitigation actions and the DRECP adaptive management and monitoring program. Likewise, there should be a clear and enforceable process for amending pre-existing permits for renewable energy developments based on new and emerging information concerning effective mitigation measures, new threats, and so on.

A key component of this recommended structure is represented by Box 10—assimilate information and formulate recommendations—which is where AMPs typically fail to adequately feed scientific information back into management and policy decisions. This function requires both policy and technical expertise, and is fundamental to the successful integration of accumulating knowledge and information into plan policies, such as revising goals and objectives, refining analytical models, or allocating funding. The link between the technical step of "Analyze, Synthesize, Evaluate" and the decision-making step of "Assimilate and Recommend" requires regular interaction and exchange of information between technical staff and decision makers.

Box 10 highlights the need for some highly skilled agent (person, team, office) to be assigned the responsibility for continually assimilating scientific information generated by investigations *both within and external to the adaptive management program* and transforming it into knowledge of the kind required for management actions. Boxes 11 through 14 indicate that such actions may include (1) refining a particular conservation measure, (2) refining the knowledge base and models of system behavior that are extracted from the knowledge base, (3) revising objectives of an entire conservation measure, and (4) reassessing whether the original target problem is solved, transformed, or still a problem. This last action may also be affected by external events such as changing societal preferences, newly recognized environmental threats, changes in available technology, or other changed or unforeseen circumstances. If new information suggests that conservation and mitigation actions codified in existing permits are ineffective, there should be a formal process for amending permits to rectify the situation.

The actions of the agent represented by Box 10 need to be carried out continually but on a range of time scales. For example, individual components of the knowledge base might be refined gradually and annually, whereas particular conservation measures might be refined only after a few years of project implementation. The entire problem might be re-assessed or re-visited once in a decade. The key principle, however, is that *the process of transferring and transforming the results of technical analyses into knowledge to support decisions cannot be taken for granted in the hope that it will occur in the absence of a body specifically charged with making it happen*. This function requires remarkably skillful people, who are truly inter-disciplinary ("polymaths"). Whatever their training, these individuals (or team of individuals) need to be comfortable with a wide range of technical information, as well as understand the functioning of government, law, economics, and the management of large projects.

6.3 Hypothesis-based Monitoring and Adaptive Management

Adaptive management is an active process in which new knowledge is gained and applied to managing natural resources (Holling 1978, Walters 1986). An overarching goal of adaptive management is to maintain optimally functioning ecosystems, with all their components (Noss and Cooperrider 1994). This necessitates understanding the dynamics of populations, communities, and the resources they need (Landres et al. 1999). Hypotheses about processes and interactions that characterize sustainable populations, as well as proximate and ultimate stressors that affect them, need to be identified. When monitoring efforts determine those stressors are evident, management experiments are used to test various means of reducing the stressor's impact. These management experiments are coupled with focused monitoring to evaluate success (Morrison et al. 2001).

Traditional monitoring approaches that focus on quantifying population size, despite increasingly high levels of statistical rigor, have generally failed to address critical questions regarding factors that affect species and community dynamics (Barrows et al. 2005, Barrows and Allen 2007). Consequently, traditional monitoring often fails to provide clear direction to management. We propose a monitoring framework that is explicitly hypothesis-based, with species monitoring performed within a context of community, landscape, and ecosystem scales. This framework approach has been published (Atkinson et al. 2004, Barrows et al. 2005) and is being adopted as a guiding philosophy for many HCPs and NCCPs throughout California. The authors of the 1994 Desert Tortoise Recovery Plan also explicitly recommended hypothesis-based research and monitoring.

This approach builds on existing published research and employs primary data collection to build conceptual and quantitative models that link species population trajectories with community or ecosystem processes and conditions (conceptual model examples: Figures 6-7). The conceptual models are essentially a collection of hypotheses regarding the drivers and stressors of a species' or communities' temporal and spatial dynamics. It is an iterative process of designing a monitoring approach and collecting data to statistically evaluate models and hypothesis by partitioning large-scale models into discrete units. This breaks down the inherent complexity of ecological systems into manageable questions. A conceptual model leads to questions that can be answered with monitoring and addressed with adaptive management. Unless the model possesses that heuristic character it is of little value.

Figure 6 illustrates a conceptual model for desert tortoise. Monitoring long-lived species like desert tortoises is often problematic, because tortoise populations can remain stable for years even with little or no reproduction, so it may take many years to detect effects of stressors on tortoise populations. However, by examining the conceptual model we can develop a monitoring design that compares different metrics, such as the incidence of diseased adults or raven predation on hatchlings, with respect to road density or other measures of habitat fragmentation. If the numbers of predated hatchlings or diseased adults exceed that of unfragmented sites, management actions should strive to mitigate fragmentation effects. Similarly, invasive species such as Sahara mustard, *Brassica tournefortii*, are thought to be a source of stress for tortoises. A monitoring strategy to address this question might test such alternative hypotheses as: (1) is the mustard density associated with fragmentation or with loss of food?; or (2) are tortoises negatively impacted by the mustard, and if so how? This latter question could be addresses by comparing tortoise condition (perhaps by a morphometric-adjusted measure of the tortoises' weight, or incidence of disease) in mustard-infested versus mustard-free landscapes. If the tortoises' condition in the mustard areas is poorer than that on the native control sites, then adaptive management strategies to control the mustard should become a priority.

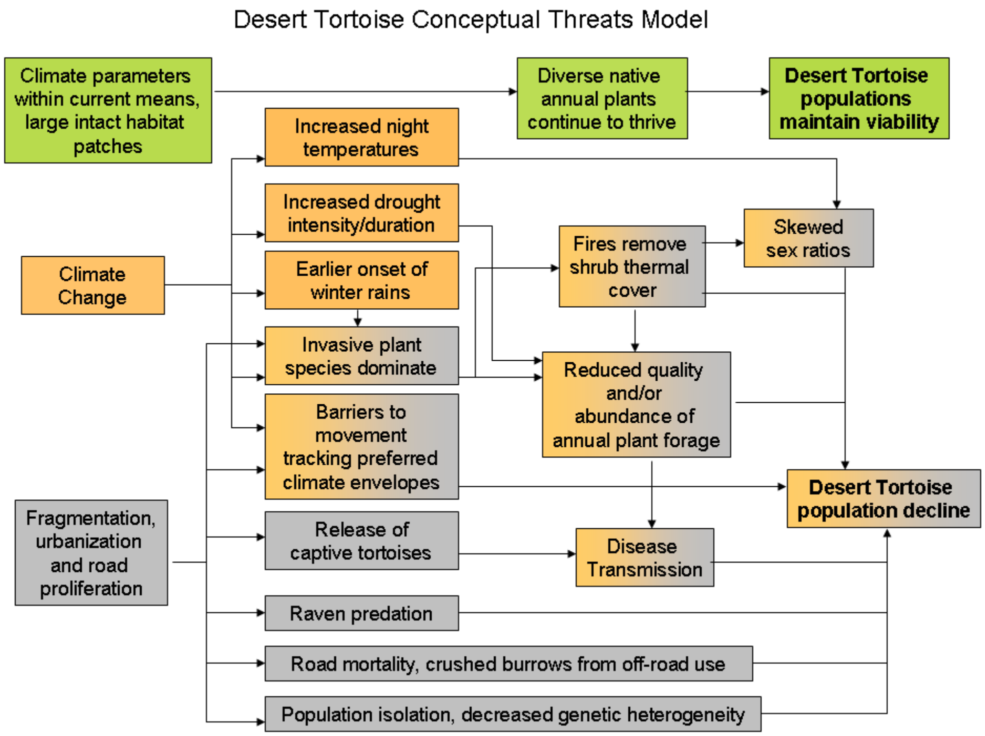

Figure 6. Desert tortoise conceptual model.

Using the Mojave fringe-toed lizard as an example of a shorter-lived species with more volatile population dynamics (Figure 7) again suggests questions about the impacts of invasive species such as Sahara mustard. Here, rather than looking at adult condition, a more straight forward approach would be to compare lizard abundances in areas with mustard and those without mustard. However to get at more proximate drivers the monitoring could also measure sand compaction and insect prey abundance with respect to the mustard as well. By measuring the mustard with respect to lizard abundance along with sand compaction and prey abundance we can evaluate whether mustard is compromising the lizards' population, and if it is, determine what pathway is driving the effect. This increases our understanding, focuses adaptive management responses, and identifies metrics for evaluating the success of mustard control measures.

Through time this hypothesis-driven process increases our understanding of how populations and communities change with respect to a range of environmental conditions. The conceptual models can be modified with new information, and ideally will evolve into quantitative, predictive models. They allow us to learn about the complex interrelationships that typify natural systems, the factors that stress natural systems, and what management tools are best used to address those stressors.

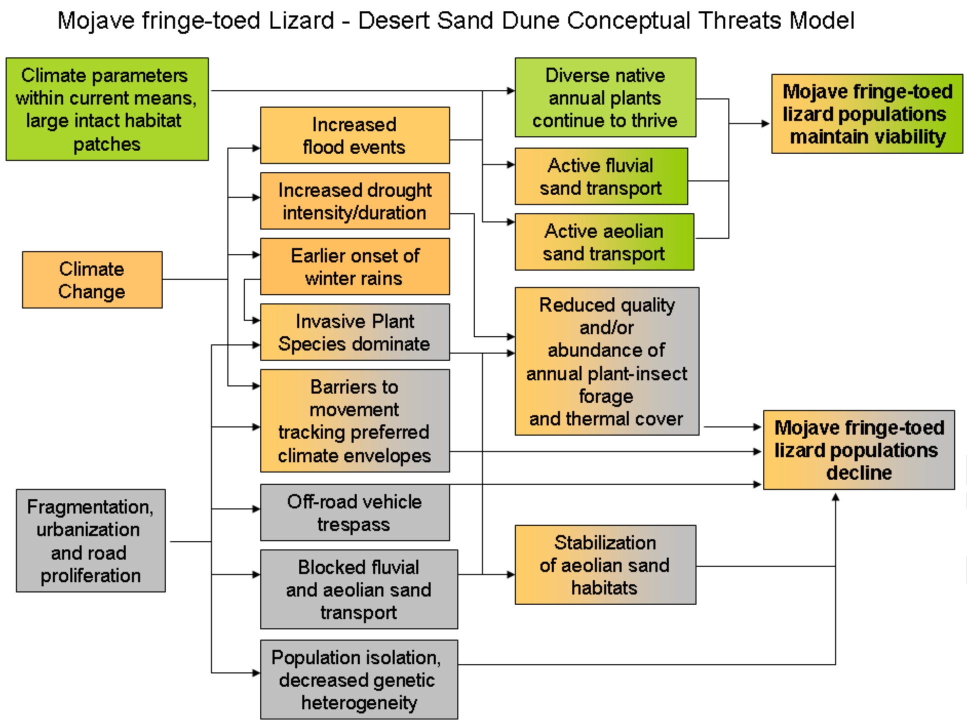

Figure 7. Mojave fringe-toed lizard conceptual model.

6.4 Monitoring Design and Research Recommendations

Renewable energy development will have impacts on species, communities, and processes that are largely unknown at this time. Mitigation for such impacts should occur via an integrated process of siting decisions, reserve establishment, and habitat management and restoration. The challenge then is to monitor both net losses and gains at various scales across the landscape. This requires systematic monitoring at impact sites, mitigation sites, and control sites (areas with no impacts or mitigation actions).

We recommend developing statistically robust monitoring designs to (1) clearly establish the effects of new developments and mitigation actions on covered species and communities, (2) better understand population distribution and dynamics of key covered or planning species, and (3) establish baseline conditions across the planning area to better understand and respond to future changes, due, for example, to climate shifts. We also endorse (4) additional research on genetic and demographic connectivity of select species' populations across the study region to better delineate important landscape connectivity areas for conservation and adaptation to climate change.

6.4.1 BACI Design for Renewable Energy Developments

Before/after - control/impact (BACI) sampling designs can be a powerful tool for understanding the impacts of anthropogenic changes on biological resources, if they are carefully designed with adequate replication and sufficient temporal sampling (Green 1979, Underwood 1994, DeLucas et al. 2005). The basic idea is to establish impact sites (e.g., areas to be developed) and control sites (those with no development) and to sample them before the impacts occur (to establish comparable baseline conditions in the two types of sites) and after the impacts occur (for sufficient duration to observe an environmental response to the impacts). Only with this sort of design can one differentiate spatial and temporal influences to better understand potential cause-effect relationships between the development and the environmental responses. A full review of potential BACI studies and their design is beyond the scope of this report, but we recommend that the plan carefully consider the range of species, ecological conditions, and impacts that could be studied with appropriate BACI designs. *A critical issue is that access to researchers must be established in potential renewable energy development areas before, during, and after development.* DRECP should establish requirements for research and monitoring access as a condition on renewable energy permits, and should use results of BACI studies to refine siting, mitigation, and other requirements for future permits.

6.4.2 Systematic Surveys for Baseline Conditions

We recommend that a comprehensive monitoring plan be designed, at the earliest stages of plan implementation, for each covered species, community, and process of interest. Monitoring sites should be established throughout the planning area; in addition to areas with expected impacts (either positive or negative). Sites should be selected from a statistical framework (e.g., random or systematic sampling, stratified appropriately based on natural communities) at an appropriate spatial scale for the entity to be monitored. Monitoring efficiencies can be generated by co-locating sample locations for multiple species or processes of concern (Manley et al. 2004).

Results of initial monitoring should be used as “baseline” data for adaptive monitoring processes, as well as for detecting and responding to changing climatic conditions. It should be expected that design and implementation of a robust program to characterize population status, distribution, or habitat associations for some covered species will take multiple years depending on status of existing information. For instance, varying levels of precipitation altered the set of habitat variables that explained occupancy patterns of Palm Springs ground squirrel (Ball et al. 2010). Time and cost required are often cited as reasons for not establishing statistically-robust, systematic monitoring programs. However, we contend that given the presumed 30-year duration of the DRECP and our strong recommendations for an adaptive approach to conservation/mitigation/restoration, investment in a systematic, multiple-species monitoring program is a vital investment in its success.

6.4.3 Population Monitoring

Accurate estimates of covered species populations are often difficult, expensive, and unnecessary. A more reasonable approach for monitoring regional populations for most species is to use presence-absence patterns and modern site occupancy estimation measures (Scott et al. 2002, Manley et al. 2004, MacKenzie et al. 2006). These approaches are able to account for surveys where probability of detection is <1, a situation which is common for many covered species. An example of such an approach has already been implemented for the Palm Springs ground squirrel within the DRECP Planning area (Ball et al. 2010). The robustness of such approaches improves when monitoring locations are selected from a probability-based sampling method across the area of interest. Efficiencies accrue from co-locating sampling locations for multiple taxonomic groups. We recommend that such an approach be considered for monitoring population status of the large number of Covered Species for which detailed population information is not available.

6.4.4 Focused Research Studies and Surveys

We recommend some focused research studies and surveys for select covered species be developed to clarify how best to conserve and manage these species. Below are some examples, but others will arise during planning:

- **Mohave Ground Squirrel Surveys**. We recommend more comprehensive surveys, using appropriate systematic or random sampling designs, to better establish the distribution, abundance, and connectivity of the Mohave ground squirrel metapopulation in the western Mojave Desert. There are large gaps in existing survey efforts, and there could additional core population areas or important connectivity areas between cores than those that have been hypothesized based on existing data (Leitner 2008). Renewable energy developments should be sited so as to avoid occupied habitats or important connecting habitats, and conservation actions should strive to secure, buffer, and connect occupied and potential habitat areas.

- **Genetic and Demographic Connectivity Studies**. We endorse proposals to use population genetic data and habitat suitability modeling to provide spatially explicit inferences about important demographic connectivity areas and movement corridors. Results could be used to refine our understanding of habitat connectivity for such key species as desert tortoise and Mohave ground squirrel to inform where to focus conservation and mitigation actions to sustain or improve population connectivity to ensure species persistence in light of habitat fragmentation and climate change. However, we also endorse genetic connectivity studies across a broader range of species, including more common or unlisted species, to better understand broader, ecological implications of fragmentation and climate change on desert ecosystems.

- **Mortality monitoring**. Guidelines for producing credible mortality estimates of bats and birds at wind energy facilities in California already exist (CEC and CDFG 2007). Importantly, mortality estimates must account for biases associated with carcass removal and searcher efficiency. The existing Guidelines (CEC and CDFG 2007) should be modified for implementation at other types of renewable energy developments (e.g., solar) and associated infrastructure within the DRECP.

6.4.5 Other Environmental Monitoring

In addition to monitoring biotic conditions and processes, we recommend that at least the following physical conditions and processes should be systematically monitored using BACI designs for new developments and to establish baseline conditions and changes throughout the planning area:

- Ground water levels and impacts—e.g., to determine whether water use or hydrological effects of developments are adversely affecting water tables and dependent resources.

- Local climate levels and impacts—e.g., to determine whether large solar arrays may affect local or regional climate conditions and hence ecological conditions.
- Erosion and deposition effects—e.g., to determine whether developments are altering soil erosion/deposition processes, eolian transport and dune maintenance processes, or levels of toxins in the atmosphere or on desert vegetation and watersheds (see Section 2.8).

6.5 Land Management Recommendations

6.5.1 Invasive Species Management

We recommend that management of exotic plants be considered as part of the energy development process and as a strategy for partly mitigating direct native habitat destruction due to energy development. It is likely that activities associated with energy development will contribute to the establishment and spread of invasive, exotic plant species. Movement of mechanized equipment can distribute seeds, construction of linear corridors (e.g., transmission lines, roads) can harbor exotics and facilitate their spread, and disturbance promotes exotic species (Lodge et al. 2006). While mitigating for direct habitat destruction by managing other lands does not fully compensate for the destroyed habitat, we suggest that managing exotics on lands adjacent to energy installations (to limit any spread of exotics due to the disturbance) and in conservation areas be considered as part of plans for partly mitigating habitat loss.

Bossard et al. (2000) summarize troublesome exotic plants of the California desert. Some species are more harmful than others. Exotic alien annuals such as Arab grass and bromes (*Schismus* sp., *Bromus rubens, B. tectorum*) now occupy over 60% of the biomass in the western, central, and southern Mojave Desert regions (Brooks and Berry 2006). The exotic annuals are highly successful, competitive, and have negative effects on native animals that rely on and prefer specific species of native food plants (e.g., desert tortoise, see Jennings 2002). Exotic annual grasses such as red brome (*Bromus rubens*) are currently of great concern to resource managers because these species are highly invasive and linked to wildfires by providing continuous fuel loads. Fires are not thought to have been prevalent historically in the Mojave Desert owing to discontinuous fuel loads, but have increased in extent in recent decades concurrently with expanding populations of exotic plants (Zouhar et al. 2008). These fires devastate native communities dominated by long-lived perennials such as blackbrush (*Coleogyne ramosissima*), which are not considered fire-adapted due to the absence of fire in the evolutionary history of the desert (Abella 2010). We suggest that an analysis of fire potential (based on fuel loads and ignition probabilities) be used as a tool for prioritizing exotic species management treatments, in conjunction with locations of sensitive species or communities with high conservation priority, and corridors where transport of exotic plants might be greatest. We recommend that equal attention be paid to high- and medium-fire potential areas. High-potential areas require treatment because of high risk; medium-potential areas can benefit from treatment to avoid becoming at risk.

Little funding for research has been dedicated to developing treatment strategies for exotic plants in southwestern hot deserts such as the Mojave. However, studies such as Allen et al. (2005) suggest that there is potential for testing different herbicides and other treatments for reducing the prevalence of red brome and other exotic plants. Key factors that should be considered in evaluations of herbicide and other treatment strategies include whether the herbicide acts as a pre- or post-emergent, the timing and duration required for effective treatment, and effects on the non-target native community. Additionally, consideration should be given to post-treatment management, as often establishing a competitive native vegetation type can reduce probabilities of resurgence of the exotic species. Since exotic species management strategies are not well tested in desert areas, these projects could take the form of applied projects that are conducted at an operational scale but within a planned study design that includes untreated controls. This can enable conclusions to be drawn about the effectiveness of candidate treatments and allow development of strategies that may be feasible to implement over the broad scales necessary to make a difference ecologically.

6.5.2 Restoration and Improvement of Habitat

We do not recommend considering habitat creation or ecological restoration as full mitigation for new habitat disturbances, although some habitat improvements and revegetation actions should be considered, in some cases, as partial mitigation for habitat destruction. Such actions might include revegetating disturbed areas (including by wildfires) with native plants within conservation reserves. Revegetation in arid lands is expensive and prone to failure due to unpredictable rainfall, and it is difficult to reestablish all features and processes of functional ecosystems. However, a recent review of revegetation practices in the Mojave Desert found that there are some examples of successful revegetation projects (Abella and Newton 2009).

Seeding and planting of greenhouse-grown or salvaged plants are the most common methods of revegetation. There are advantages and disadvantages to both methods; for example, larger areas can be revegetated through seeding than through planting. Associated treatments, including protecting seeds and plants from being eaten, can make the difference between successful and failed projects. Abella and Newton (2009) compiled a list of the performance of an array of native species in revegetation projects as well as the effectiveness of treatments. In addition, restoration activities such as reestablishing native riparian vegetation and hydrological patterns along springs and water courses could greatly improve habitat value and provide an adaptation strategy if the climate changes (Seavy et al. 2009). This is especially appropriate for renewable energy facilities that require significant amounts of water and may further stress groundwater supplies. Restoration efforts should not focus solely on "cosmetic" areas such as campgrounds or visitor centers, but should include meaningful areas for habitat conservation improvement purposes.

To the degree feasible, we suggest considering maintaining natural vegetation within renewable energy installations to maintain some habitat value, but carefully monitoring how this affects ecological communities and covered species. The current paradigm is to bulldoze the soil and vegetation to establish energy sites. Assessing alternative strategies that include retaining as much vegetation as possible would be a large improvement over clearing all vegetation. It is possible that that some vegetation can coexist with energy installations to provide some habitat as well as to sequester carbon. An initiative to incorporate vegetation within energy installations should include balancing any conflicts of retaining vegetation with fire hazard, maintenance and performance of the energy structures, and the ability of the vegetation to grow within the energy sites. If vegetation can co-exist within arrays, the best strategy would likely be to leave mature plants (i.e., not bulldoze them in the first place), as opposed to trying to revegetate after the fact.

However, it is uncertain what type of native plant species are best adapted to co-exist with energy sites, so species that can thrive with shade cast by solar structures and other aspects of the sites may need to be identified and promoted. In addition, where energy installations are sited by leasing private agricultural land or private or public abandoned agricultural land, it may be possible to grow crops (or restore native desert vegetation) in concert with energy structures. Using agricultural land for energy installations has many advantages (e.g., the land is already relatively level) and is a strategy we recommend.

Monitoring should also consider whether maintaining some habitat value within renewable energy developments may do more harm than good, for example by attracting species into areas with high mortality rates. In this case, habitats within energy developments may be "sink habitats" where mortality exceeds reproduction. If this effect is strong, it has potential to reduce regional populations of covered species. Answers to such questions should be answered early if possible, by carefully designed BACI monitoring studies at developments that are permitted in the near future.

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